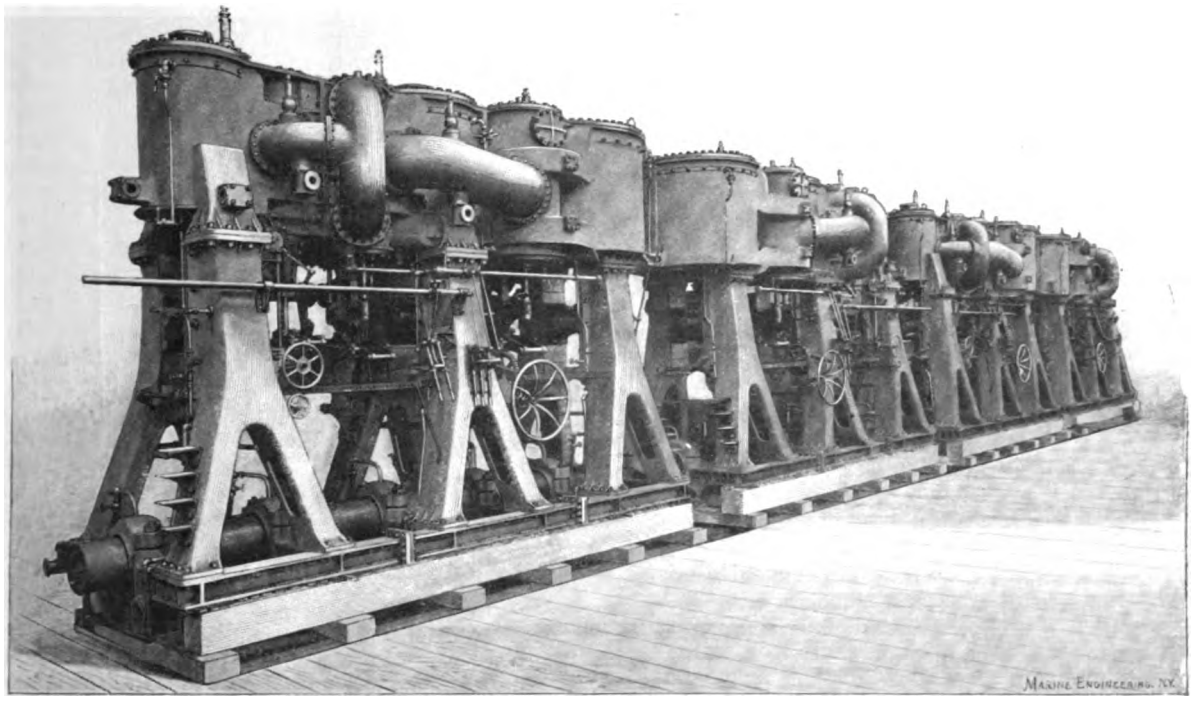
MARINE ENGINEERING.

Vol. 1. NEW YORK, JULY, 1897. No. 4.

U. S. ARMORED CRUISER BROOKLYN PRESENT AT BRITISH NAVAL REVIEW.

The United States Navy was worthily represented at the great naval review held at Spithead, June 26, in honor of the Diamond Jubilee of Queen Victoria. At the review there were 150 ships of the British Navy in line, and in addition ships from the world's navies and many fine mercantile vessels. The Brooklyn was selected as a representative vessel of the latest practice here in armored cruisers. It is consequently appropriate at this time to give some details of her construction and equipment.



TRIPLE-EXPANSION ENGINES OF U. S. ARMORED CRUISER BROOKLYN.

U. S. S. Brooklyn is a twin screw armored cruiser of 9,270 tons displacement. She is 400 ft. 6 in. long between perpendiculars, 64 ft. 8 in. beam, and her mean draught when ready for sea is 24 ft. The contract for her construction was awarded the William Cramp & Son's Ship and Engine Building Co., of Philadelphia, Pa., in February, 1893, at the price of $2,986,000. The keel was laid in August following, and she was sent on her trial trip in August, 1896. The contract called for a speed of 20 knots for four consecutive hours, and on her trial trip she showed an average speed of 21.91 knots, and a maximum speed of 22.9 knots, earning a bonus of $350,000 for her builders.

The hull is of mild steel divided into 242 water tight compartments. There is a double bottom amidships, and a cofferdam runs along each side of the entire length between the berth and protective decks. This is filled with cellu-

Digitized by Google

lose. The top of the protective deck is level with the water line, and is 3 in. thick, curving downward at the sides with an increase of thickness to 6 in. At the ends the thickness is reduced to 2 1-2 in. This deck joins the hull 5 ft. 6 in. below the water-line. The machinery spaces are further protected by a belt of Harveyized armor 3 in. thick, extending along the sides for about 200 ft. and 4 ft. above and below the water-line. Coal is also carried above the protective deck almost the entire length of the machinery spaces, and also in bunkers below this deck. The bunker capacity is about 1,700 tons.

The Brooklyn stands high out of the water, having 29 ft. freeboard at the bow, and 21 ft. at the stern. She has two military masts and three very tall and rather slender smoke stacks, which combination gives her a very "machine" appearance. The tops of the funnels are 100 ft. above the grates, and 45 ft. above the deck superstructure.

Her armament consists of eight 8 in. guns, mounted in pairs in four barbette turrets, one forward and one aft, and one on each side amidships. The amidship guns can be fired in any point of a half circle from right ahead to right astern, as the sides tumble home sharply. The barbettes are plated with 8 in. and 4 in. armor, and the turrets with 5 1-2 in. armor. A supporting tube of 3 in. armor under each turret extends down below the protective deck and protects the ammunition hoists inside. There are also twelve 5 in. quick fire guns, mounted in sponsons on the gun deck, protected by armor 4 in. thick. There are also carried twelve 6 pounders, four 1 pounders, and four machine guns. A torpedo equipment for above-water discharge is fitted. The conning tower and shield forward are of solid steel, 7 1-2 in. thick.

The machinery equipment of the Brooklyn is, as might be supposed, very extensive. There are four main engines, seen in the illustration, of the three cylinder triple-expansion type, each with 3 cranks set at 120 deg. Each engine occupies a separate water tight compartment, though all connect with doors on the starting platform level. There are two engines on each shaft coupled together with taper coupling bolts, so that the forward engines can be disconnected with comparative ease. The engines are set with the high pressure cylinders forward, and the reversing gear and telegraphs are inboard. Bed plates and frames are cast steel, the latter in shape an inverted Y. On the insides of the frames, ribs are cast, and to these the cast iron crosshead guides are secured, with a space left for water circulation. Each engine has cylinders 32 in., 47 in., and 72 in. dia. and 42 in. stroke, fitted with liners. Steam jackets are fitted to the I. P. and L. P. cylinders, and provision is made for the expansion of the I. P. and L. P. liners at the tops. The valves are single-ported piston, of cast iron, one of 16 in. dia. for the H. P. and two of 16 in. for the I. P. These are fitted with balance pistons 4 in. and 4 3-4 in. dia., respectively, connected on top with the main condensers. The low pressure valves are two in number, the upper 30 in. dia. and the lower 28 1-2 in. dia., with live steam between, so as to effect a balance. The valve gear is of the regular Stephenson double bar link pattern. The pistons are of cast steel, dished, each fitted with two rings 5-8 in. wide and 3-4 in. deep. The rods are of steel 6 3-4 in. dia., and the crossheads are bolted to cast steel slippers lined with white metal. The crosshead pins are 7 in. dia. and 8 in. long, bored with a 2 1-2 hole. The connecting rods are 7 ft. between centers. The crank shafts are forged steel, built up. When the two engines are coupled together on each shaft, the H. P. cranks are opposite. The crank shafts of the forward engines are 27 ft. 6 in. long, 13 1-2 in. dia., with a 6 in. hole. The crank pins are 13 1-2 in dia. and 17 in. long. The dimensions of the crank shafts of the after engines are: length 24 ft. 10 in., diameter, 17 in. with a 7 in. hole, with journals 15 in. dia., and crank pins 17 in. dia. and 14 1-2 in. long. The crank shaft bearings are fitted with bottom brasses and cast steel caps, all lined with white metal, and arranged for water circulation. The main steam pipes are 12 in. dia., of copper strengthened with 1-8 in. steel bands, spaced 6 in. apart. Steam is carried between the various cylinders and condensers by outside pipes of composition, fitted with expansion joints. The reversing gear is so arranged that the two engines on one shaft can be simultaneously regulated from either engine room. A disk stop valve, with balancing piston and butterfly throttle is fitted to each engine. The thrust blocks are fitted close up to the after engines. The pedestals are cast iron of horse shoe form, lined with composition. The thrust shafts are 16 3-4 in. dia. and 12 1-4 ft. long, with a 7 1-2 hole. There are 12 collars on each shaft, 21 3-4 in. dia. and 2 in. thick, spaced 3 in. apart. The propeller shafts are in two sections, 18 in. and 17 in. dia., with 11 in. holes and 72 ft. long. They are splayed, and the outboard ends are carried in heavy steel brackets set close to the propeller hubs. The bracket bearings are 25 in. dia. and 34 in. long. The propellers are of manganese bronze, 3 bladed, true screws 16 1-2 ft. dia. with adjustable pitch normally about 20 ft.

Coming back to the engine room, the main condensers are of cast brass, 10 ft. 9 in. long and 5 ft. 9 in. dia, each fitted with 3,684 tubes, having a cooling surface of 5,425 sq. ft. The tubes are 5-8 in. O. D., 20 B. W. G., spaced 15-16 in. centers. Each engine is provided with one double vertical Blake air pump, with steam cylinders 12 in. dia., and water cylinders 25 in. dia. and 18 in. stroke. A centrifugal circulating pump is fitted for each condenser. Each is driven by a horizontal engine, with a 12 in. by 9 in. cylinder. The suction and discharge pipes are 14 in.

Digitized by Google

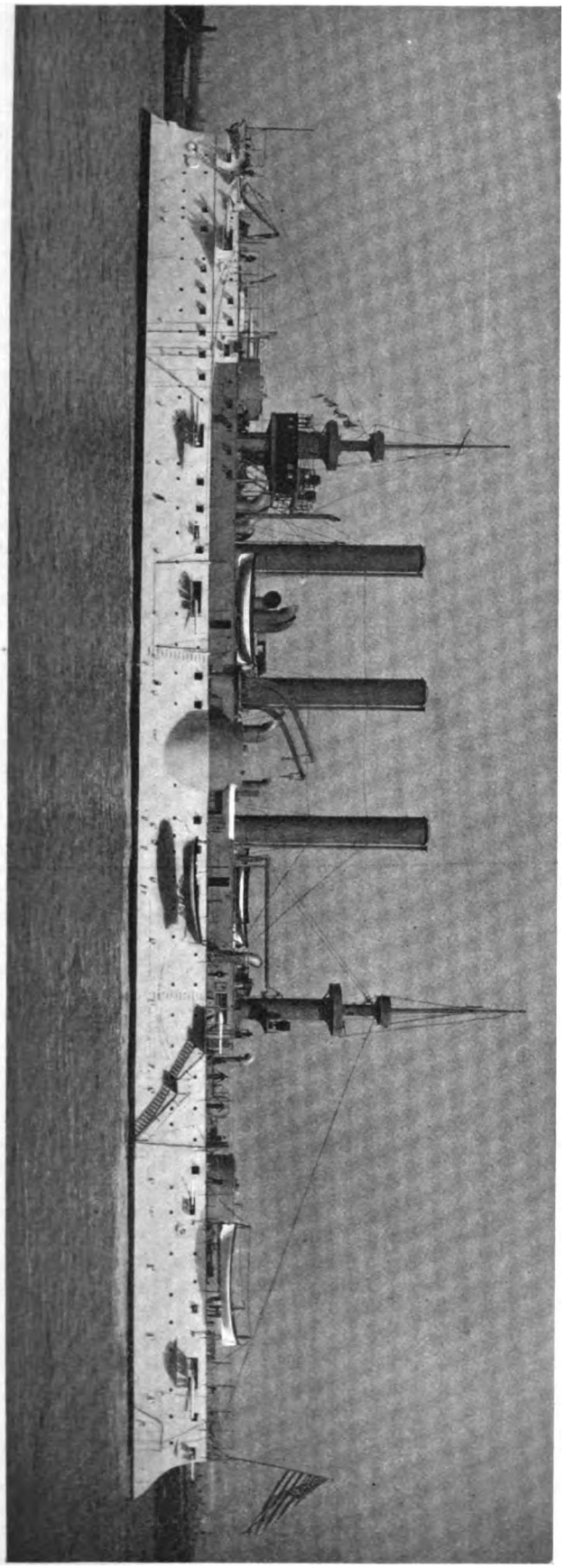
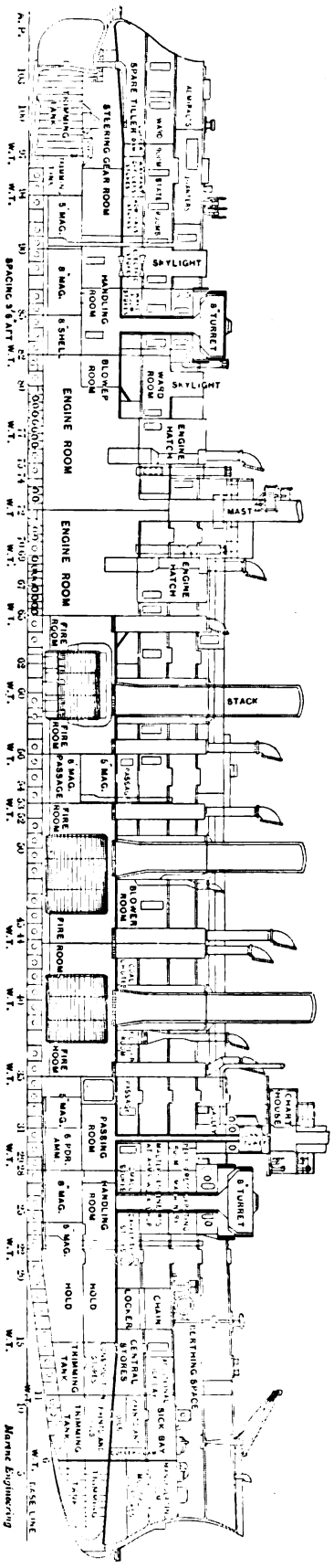


Photo. copyrighted 1897, by Geo. P. Hall & Son, New York.

U. S. ARMORED CRUISER BROOKLYN IN N. Y. HARBOR BEFORE HER TRIP ACROSS THE ATLANTIC.



LONGITUDINAL SECTION U. S. ARMORED CRUISER BROOKLYN.

Digitized by Google

Steam at 160 lbs. is supplied by five double ended and two single ended boilers, 16 ft. 3 in. dia. Four double ended are 18 ft. long, and one 19 ft. 11 1-2 in. long, and the single boilers are 9 ft. 5 in. long. There are eight Fox's furnaces in each double ended boiler, and four in each single ended boiler. All boilers are under the protective deck in three water tight compartments, and are fired athwartships. Armor bars are fitted inside the smoke pipes. In the double ended boilers there are 904 tubes, 2 1-4 O. D. and 296 stay tubes. The single ended boilers have 466 plain tubes and 152 stay tubes of 2 1-4 in. dia. All are fitted with shaking grates. The grate surface of all the boilers is 1,016 sq. ft. and heating surface 33,432 sq. ft., or a ratio of heating surface to grate surface of 32.9 to 1. Forced draught on the closed stokehold system is used. Each fireroom has two Sturtevant blowers, with double engines, 5 in. by 4 in. and fans 60 in. dia. and 18 in face.

Auxiliary machinery is numerous, and includes auxiliary condensers, feed pumps, fire bilge and water service pumps, turning engines, grease extractors, steam traps, ash hoists, ventilating blowers, distilling apparatus, turret turning engines, ice machine, machine tools and engine, and various other minor engines. The electric plant is extensive, consisting of three separate sets of generators, each with a capacity of 400 amperes at 80 volts. All of the machinery aboard, including the water, weighs 1,543 tons.

On her official trial the four main engines of the Brooklyn developed 18,248 horse power, and all of the machinery in operation gave a total of 18,769 horse power. The main engines averaged a little in excess of 136 revolutions with the boiler pressure at 158 lbs., the vacuum 25 in. and the throttle wide open. The average speed was 21.91 knots. This was on a displacement of 8,150 tons. The air pressure in the fire room was 2.26 in., and the boilers gave steam freely. The temperature in the engine room was 100 deg. and in the fire room 118 deg. Fahrenheit. The proportions of indicated horse power, taking into account all of the machinery in operation were, per sq. ft. grate surface, 18.47; heating surface, .56; cooling surface, .81; per ton of machinery, 12.16. With the after engines alone the Brooklyn can maintain a speed of 17 knots. At full speed she has a radius of action of 1,758 knots, and at 10 knots, cruising speed, of 6,088 knots. Her officers, and men number 560.

For many of the foregoing particulars and for the section we are indebted to the Journal of the American Society of Naval Engineers.

Accurate details of her run across the Atlantic are not yet obtainable, though telegraphic advices report a very satisfactory trip with a good record for economy.

Plans for the hull were drawn by the Bureau of Construction and Repair, and the machinery was designed under the supervision of Engineer-in-Chief George W. Melville, U. S. N.

STEAMSHIP VIBRATIONS WITH RECORDS OF RECENT OBSERVATIONS.—2.

BY PROF. W. F. DURAND.

In the preceding paper the causes of ship vibrations and the immediate results of these causes furnished the subject of discussion. We have next to examine the means available for the diminution or more or less complete suppression of such vibratory motion. The ideal solution, will of course, involve the removal of the exciting cause, and this should be the object of first attention in our examination of the problem before us.

Taking first the case of a single crank engine and omitting the influence due to valves and valve gear, we will examine in some detail the amount and distribution of the forces due to the inertia of the principal moving parts. These may be conveniently considered under three heads: (1) The reciprocating parts including the piston, piston rod, and crosshead; (2) The connecting rod, and (3) The crank. We may also consider the forces under the two heads of vertical and horizontal, of which naturally in vertical marine engines the former is the more important.

These forces may also be represented in two ways. The first of these is shown in Figs. 1 and 2. Counting from the position of the crank when on the center nearer the cylinder, crank angles are laid off on the base line OX, and the corresponding forces, vertical or horizontal as the case may be, are laid off vertically, thus giving the various curves as shown. These give for the entire revolution graphic histories of the vertical and horizontal forces due to the various parts above enumerated. These forces are computed for the moving parts of the high pressure cylinder from the data furnished by the design of a triple expansion engine of the following chief dimensions.

Diameter and stroke, 26", 41 1-2", 66" x 45"	
Revolutions per minute	100
Ratio of connecting rod to crank	5 : 1
Weight of reciprocating parts	2,155
" " connecting rod	2,770
" " crank	2,767

The second method of representation is illustrated in Fig. 3. In this diagram the crank positions are denoted by radii drawn to the circle ABCD. The radius of this circle is of such length as to represent the maximum value of the horizontal force, or the value for a crank angle of 90°. Then in any given crank position OP, the horizontal projection OQ will represent the horizontal force for such position. QR is then laid off to represent the total vertical force for the same position, and OQ will therefore give the total resultant force in both direction and amount. For the entire revolution the representation will take the form MRBND. In general, as is seen, the resultant direction does not coincide with that of the crank. In such a diagram the total force for any weight having rotary motion alone, such as the crank or a shaft counterbalance, is represented simply by a circle. Thus EFGH

Digitized by Google

represents the force due to the crank, while KBLD plotted in the same way as MBND shows that due to crank and connecting rod combined. The circle ABCD shows the part of the total force equivalent to that furnished by a rotating weight. Such weight in this case is represented by the crank plus 55 per cent of the connecting rod considered as having its center of gravity coincident with that of the crank pin. With these circular diagrams the crank being in any position represented by P or S, the radii OP or OS give the constant total force, while the projections OQ and OT or PQ and ST give the horizontal and vertical components.

These diagrams represent the forces for an actual design as given above, and are determined by means of formulæ given in the appendix. With the general character of these curves before us, it is easy to see the nature of the effect due to any weight or system of weights used as counterbalances, and having motions similar to those of the moving parts of the engine. Thus for a rotating shaft counterbalance, the history

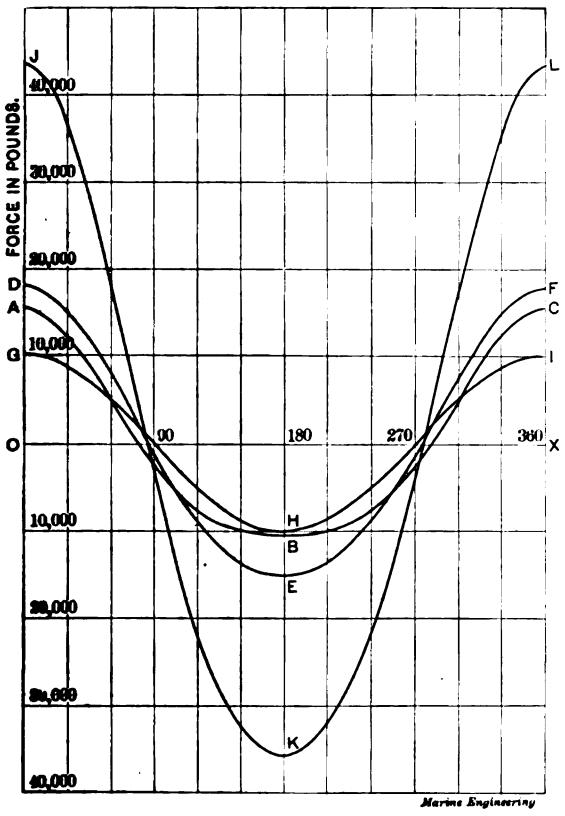


FIG. 1.

ABC—Vertical force due to the reciprocating parts.
DEF—Vertical force due to the connecting rod.
GHI—Vertical force due to the crank.
JKL—Vertical force due to the principal moving parts=sum of the preceding three

would be given by a circle in Fig. 3 as already noted. In no case, however, can such a weight produce a complete balance. If it be so taken as to give a constant radial pull equal to OB, and directed opposite to that of the crank, then it may be readily seen that the horizontal forces will be balanced. In such a case, however, a large unbalanced vertical force will still exist as shown by the diagram. Due to the unsym-

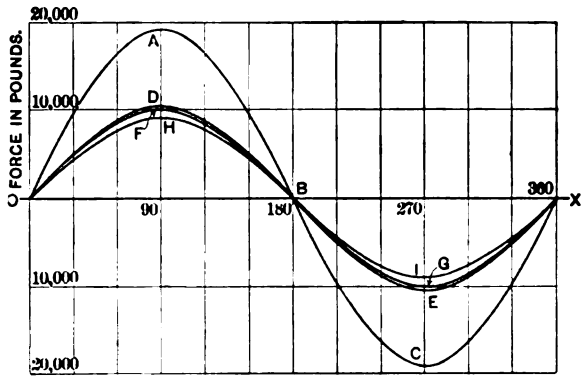


FIG. 2.

OFBGX—Horizontal force due to the crank.
ODBEX—Total horizontal force due to connecting rod.
OHBIX—Horizontal force at crank pin due to connecting rod.
OABCX—Total horizontal force on crank shaft.

metrical form of this diagram, a result due to the angularity of the connecting rod, no such weight can balance the vertical forces. A weight so taken as to give a force represented by OU for example, would be the nearest approximation, but there would still remain unbalanced forces as shown. In such case also, new unbalanced horizontal forces would be introduced by the counterbalance as shown in the diagram. Thus with the crank at P, OQ and QR are the horizontal and vertical forces due to the parts of the engine, while OV and VU are those due to the counterbalance. The differences are apparent. An examination of KBLO shows that a rotating counterbalance can be so determined as to nearly balance the forces due to the crank and the connecting rod combined, but without the reciprocating parts. Such a weight might be so taken as to give a radial pull represented by OB, thus balancing the horizontal forces and leaving the vertical remnant as shown, or it might be so taken as to give a pull represented by OW, thus balancing as closely as possible the vertical forces and introducing a horizontal unbalanced component.

The result of attempting to counterbalance the entire system of forces by a rotating weight giving a radial pull as represented by OU has been already referred to. If it is desired to counterbalance as nearly as may be the entire system of vertical forces without thus introducing large additional horizontal forces, then the counterbalances must take the form of weights having motion similar to that of the parts to be counterbalanced. This plan has been used to some extent on small boats, and the counterbalances thus employed are termed bob-weights. The plan was first brought prominently forward by A. F. Yarrow, whose paper read before the

Digitized by Google

Institution of Naval Architects may be consulted for further details.[1] The weights are actuated by a connecting rod given motion by an auxiliary crank or an eccentric. Obviously the forces due to these actuating parts must be taken account of, and they may be made to answer as part of the shaft counterbalance. With bob-weights the balance of vertical forces is only approximate, and usually less perfect than could be obtained by a rotating weight. This is due to the angularity of the connecting rod which actuates the weights. Thus if it were the same as that of the main connecting rod and the weights of the counterbalance system were the same part by part as those of the moving parts of the engine, the vertical force developed by the former would be represented in Fig. 1 by shifting ABC along 180°. The result of the combination would be a residual force shown by ABCDE Fig. 4. If the balance were effected by a rotating weight the residual vertical force is readily determined from Fig. 3, and is represented in Fig. 4, by FGHIJ. The latter of these residuals is about one-half the former, and it will be noted in each case that the period is one-half that of the fundamentals, or in other words that there are twice as many alternations per minute as with the original forces.

For the determination of the counterbalance weights in the various cases discussed, the most satisfactory method will be through actual investigation by means of such diagrams as those here shown. In default of such methods, approximate values may be found by means of the following rules:

If a shaft counterbalance is to be used to give a force represented by OB Fig. 3, it must be located opposite the crank, and its moment or the product of its weight by the distance of its center of gravity from the shaft center must equal the similar product for the crank, plus the product of about one-half of the connecting rod weight by the crank arm. In the present case the weight of the cranks webs and pin is 2767 pounds, while their center of gravity is 1.07 feet from the shaft center, the weight of the connecting rod is 2770, and the crank arm is 1.75 feet. Hence the sum of the moments would be $2767 \times 1.07 + 1385 \times 1.75 = 5374$ and the counterbalance weight multiplied by its arm must equal this amount. Thus use might be made of 5374 lbs. at an arm of 1 foot, or 2687 lbs. at an arm of 2 feet, etc. In the present case, as we have seen above, the more accurate value for the fraction of the connecting rod weight is .55 instead of .50. If a shaft counterbalance is to be fitted so as to balance as nearly as may be the entire vertical force irrespective of the additional horizontal forces introduced, then the product of its weight by the distance of its center of gravity from the shaft center must equal weight of reciprocating parts multiplied by the crank arm, plus the weight of connecting rod multiplied by the crank arm, plus the moment of the crank as before. This sum will be of frequent recurrence in the course of our examination, and for convenience we will designate it as the *characteristic moment* of the moving parts. The similar sum for the parts of a counterbalance system consisting of shaft counterbalance, auxiliary crank, connecting rod, and bob-weights, will comprise the product of the bob-weights by the auxiliary crank arm, plus the product of the auxiliary connecting rod by the same arm, plus the moments of the auxiliary crank or eccentric, and of the shaft counterbalance, about the shaft axis. This may be called similarly the *characteristic moment* of the counterbalance system. If the system consists of a shaft counterbalance alone, the characteristic moment is simply the moment of the weight about the shaft axis. In the present case the weight of the reciprocating parts is 2155.

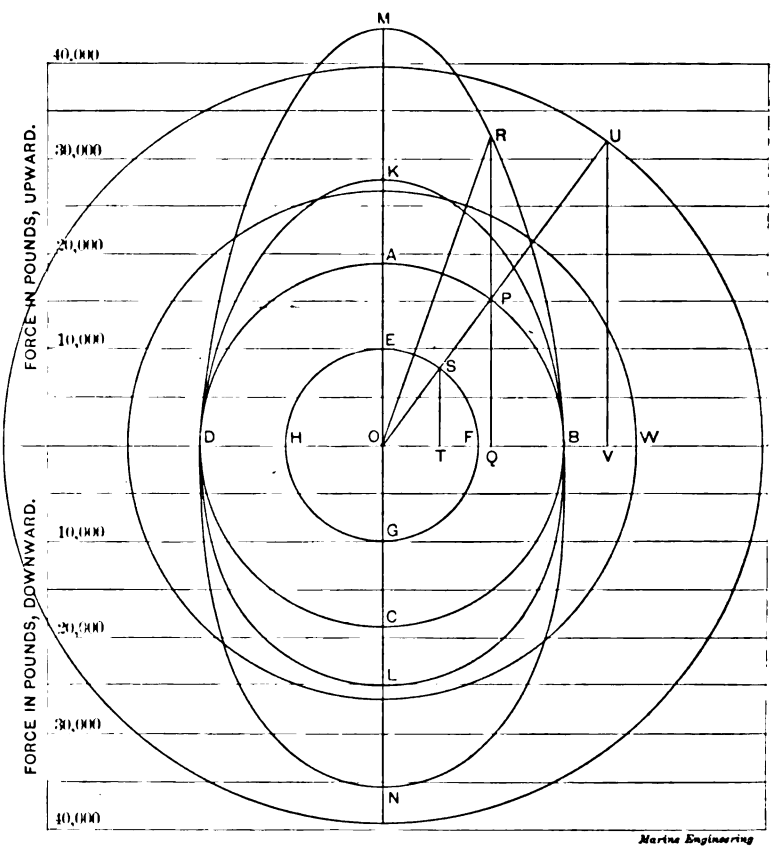


FIG. 3.

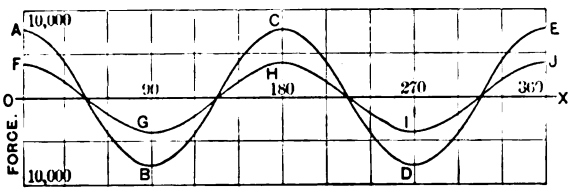
[1] Vol. XXXV, p. 213, 1894.

Digitized by Google

Hence the characteristic moment of the moving parts is:

$$2155 \times 1.75 + 2770 \times 1.75 \quad 2767 \times 1.07 \quad 11580$$

and the counterbalance must be so arranged as to give the same moment. If a combination of



CRANK ANGLES. FIG. 4.

shaft counterbalance and bob-weights is to be used, the characteristic moment of the system must have the same value. In fact the general rule for complete vertical counterbalance requires that however the weights may be divided between shaft counterbalance and bob-weights with their actuating parts, the characteristic moment of the system must equal that of the moving parts of the engine.

Where a shaft counterbalance alone is used, the vertical balance, or that in the direction of the line of motion is more commonly partial rather than complete, and in consequence the moment of the weight would vary between the limits defined as above (in the present case 5374 to 11580), according to the relative importance of a balance of forces in a direction at right angles to the line of motion, or in the direction of the line of motion.

We have thus considered in some detail the balancing of the forces due to the principal moving parts of a single crank engine, for the reason that the principles developed may be readily extended to the more general case of multiple cranks and valve gears. Omitting, however, for the present, the influence due to valve gears, we will proceed with the simpler combinations of cranks. Thus with two cranks at right angles the general result must be obtained by a combination of the curves for the principal moving parts of each engine. In such case if the moving parts are of the same weight the maximum forces up and down will be of the same value, and a complete and practically perfect counterbalance can be obtained by a weight at 135° from either crank and having a moment about 1.4 times the characteristic moment for the moving parts of one engine. If a combination of shaft and bob-weights is to be used, their characteristic moment must have approximately the same value. If the moving parts are not of the same weight the case will require detailed consideration, and the resultant force diagram will give the necessary data for determining the location and amount of weight for counterbalance. An approximate value will be found by taking .70, the sum of the characteristic moments for both engines, and locating it at an angle somewhat greater than 135° from the crank belonging to the heavier parts.

If the two cranks are opposite it is evident that each set of moving parts may be considered as a counterbalance system for the other, and if the moving parts are of the same weight the balance will be complete but not perfect. This point has been referred to above in connection with Figs. 1 and 4, and arises from the angularity of the connecting rod. The residual force is by no means inconsiderable, being in the case of a pair of engines such as here considered, and as shown by Fig. 4, of a maximum value of about 8,000 pounds in each direction, and thus giving a total change of stress of 16,000 lbs. twice in each revolution. The importance of these residual forces was first prominently brought out by Messrs. Robinson and Riall-Sankey in a paper read before the Institution of Naval Architects, to which further reference may be made.[2] If the moving parts are of unequal weight, a counterbalance system must be used of angular location opposite the crank belonging to the heavier parts, and of characteristic moment equal to the difference of those for the two sets of moving parts.

Turning now to the engine with three cranks at 120° and with equal weights of moving parts, we should find by plotting three curves similar to JKL Fig. 1, with an angular difference of 120° that the residual force would very nearly vanish. Such an engine is therefore self-balancing so far as the residual forces are concerned. If the moving parts are not of the same weight, the case will require detailed examination, and the result of the combination of the three curves plotted with 120° angular interval, and taking note of the crank sequence, will show the amount and angular location of the maximum forces, and hence the characteristic moment and angular location of the necessary counterbalance system. If the curves for the three cylinders are combined with some angular relation other than 120°, the result will show whether such a combination is better or worse than that given by the regular 120° relationship. A series of trials in this way would serve to determine an angular relation for any given engine for which the resultant force would be a minimum. Such an investigation may preferably be carried out in the following manner. Any two curves are taken, as for example those for the high and intermediate, and combined at a series of angular intervals until a result is found such that the mean of the extreme values is as nearly as possible the same as the mean for the remaining or low pressure cylinder. The angle thus determined between the high and intermediate is then noted and the location of the maximum and minimum for their resultant will show at what angle the low pressure crank should be connected in order to produce the nearest approach to a perfect balance. Thus with the engine used for illustration the total vertical force for the H. P. cylinder varies from about 43,300 upward to 35,500 downward. For the I. P. the corresponding figures are 47,100 and 38,000, and for the L. P., 56,500 and 44,300. If now these are com-

[2] Vol. XXXVI, p. 300, 1895.

Digitized by Google

bined with crank intervals of 120° we shall find a resultant force varying from about 11,500 upward to 9,000 downward. If, however (the sequence of cranks being High-Intermediate-Low, in the order of passing a given point), the angular interval between the high and intermediate is made 105°, and that between the intermediate and low 129°, the resultant force is reduced to about 5,000 in each direction, or about one-half the former range. A system of counterbalances could do but little better, so that by such an arrangement of cranks the engine may be made self-balancing within the limit usually attained.

Passing now to the four-crank engine we find for 90° crank intervals, and equal weights of moving parts, practically a perfect balance. This is readily understood when we remember that the four-crank engine may be considered as two pairs of two crank engines for each of which the residual force is represented by a curve as ABCDE, Fig. 4. The final resultant will therefore be that due to a combination of two sets of such curves with 90° angular interval, and this, as is seen, is practically O throughout the revolution. If the weights of the moving parts are not the same, a special examination will be required, from the results of which the necessary characteristic moment and angular location of a counterbalance system can be determined. In particular it may be noted that with the moving parts of say cylinders 1 and 2 equal with cranks at 180°, and those of cylinders 3 and 4 equal with cranks at 180°, the two pairs of cranks being at 90°, but the weights of 1 and 2 being different from those of 3 and 4, the combination will not give a perfect balance. The result will be represented by the combination at 90° interval, of two unequal sets of curves like ABCDE Fig. 4, and will give a residual alternating force of two complete periods per revolution. In a similar manner as for three cranks, a special arrangement of the four cranks may be found for any given case with different weights of moving parts, such that the balance will be as nearly perfect as possible, and thus the use of special counterbalance may be avoided.

Turning now to the forces introduced by slide valves and gear, we note that the parts may be reduced approximately to the same heads as in the case of the principal parts of the engine, and hence the same formulæ and methods apply without change. We may thus derive for each valve gear a series of curves similar to those above described, and such that when combined at the proper angular intervals with those for the principal parts of the engine, the result will give the total force due to all moving parts. In general with valve gears the angularity of the rods and the total forces are relatively small so that no serious error will be introduced by neglecting the angularity, and taking in each case the vertical force as given by what we have called the characteristic moment for the gear, multiplied by the square of the angular velocity and by the cosine of the angle made with the vertical, and divided by the value of gravity. This would be equal to the vertical force due to a revolving weight on the main shaft having a moment equal to the characteristic moment of the valve gear.

We have thus far examined the question of a balance of the inertia forces considered only with reference to the force resultant. Attention must also be given to the resultant moment as applied to the shaft or bed plate. Thus suppose for a single engine that a single shaft counterbalance were located in the proper angular relationship, but at some distance from the crank. The result of the vertical forces, as is readily seen, would be a rocking moment on the shaft tending to impart a see-saw motion to the engine, the more severe as the moment arm is greater. Similarly if a single bob-weight were connected to an auxiliary crank at some distance from the main crank, the result would be the same. It is readily seen that like conditions will result for two cranks at 180° and for various other arrangements of cranks. The entire system of forces due to the parts of the engine and to the counterbalance system or systems must therefore be considered and adjusted as nearly as may be, so that the vertical resultant and the vertical moment shall both vanish. To this end the history of the rocking moment for the unbalanced engine throughout the revolution must be obtained. This may be found from the curves of resultant vertical force similar to JKL, Fig. 1. Taking three cranks for illustration, we may use the L. P. center line as the origin of moments. We then take for a given angle the vertical forces for the H. P. and I. P. cylinders, and multiply the former by the distance between the H. P. and L. P. center lines, and the latter by the distance between the I. P. and L. P. center lines, and combine the products according to sign. Forces upward may be taken as positive and downward as negative. Thus a positive product would denote a moment tending to elevate the forward end of the engine and to depress the after end, and a negative product vice versa. The result thus found will give therefore the rocking moment for the angle taken. These results being plotted on a horizontal axis of angle as in Fig. 1, the entire history of the rocking moment will be known. In general it will be found periodic in character, showing a tendency to rock the engine to and fro longitudinally once in each revolution. A counterbalance weight or system may then be introduced at the proper angle as shown by the resultant curve, and of proper size and at the necessary distance from the L. P. center line, to give approximately a numerically equal moment of opposite sign, and thus to effect an approximate balance of rocking moments. In the determination of this counterbalance three specifications are required. (1) Angular location. (2) Moment about shaft axis or characteristic moment as defined in connection with a counterbalance system. (3) Location relative to L. P. center line. Item (2) may be taken the same as

Digitized by Google

for the balance of vertical resultant force, and (3) so determined as to give the necessary moment. In general, however, (1) will not agree with the requirement for vertical resultant force, and (3) moreover may give a location far beyond the limits of the engine proper. If the engine and ship formed one rigid whole, the location of the counterbalance system far from the engine would not render it ineffective. But practically the flexibility and elasticity of the structures with which we have to deal, require all counterbalances to be applied at or very near the engine. If item (2) is made larger so as to reduce the distance from the L. P. center line, then the vertical resultant will be no longer approximately balanced. It will thus be found in general that with cranks at equal angles the conditions for the nearest possible balance of vertical forces and of rocking moments cannot be fulfilled at the same time. We shall recur at a later point to such cases as do admit the approximate fulfilment of these conditions.

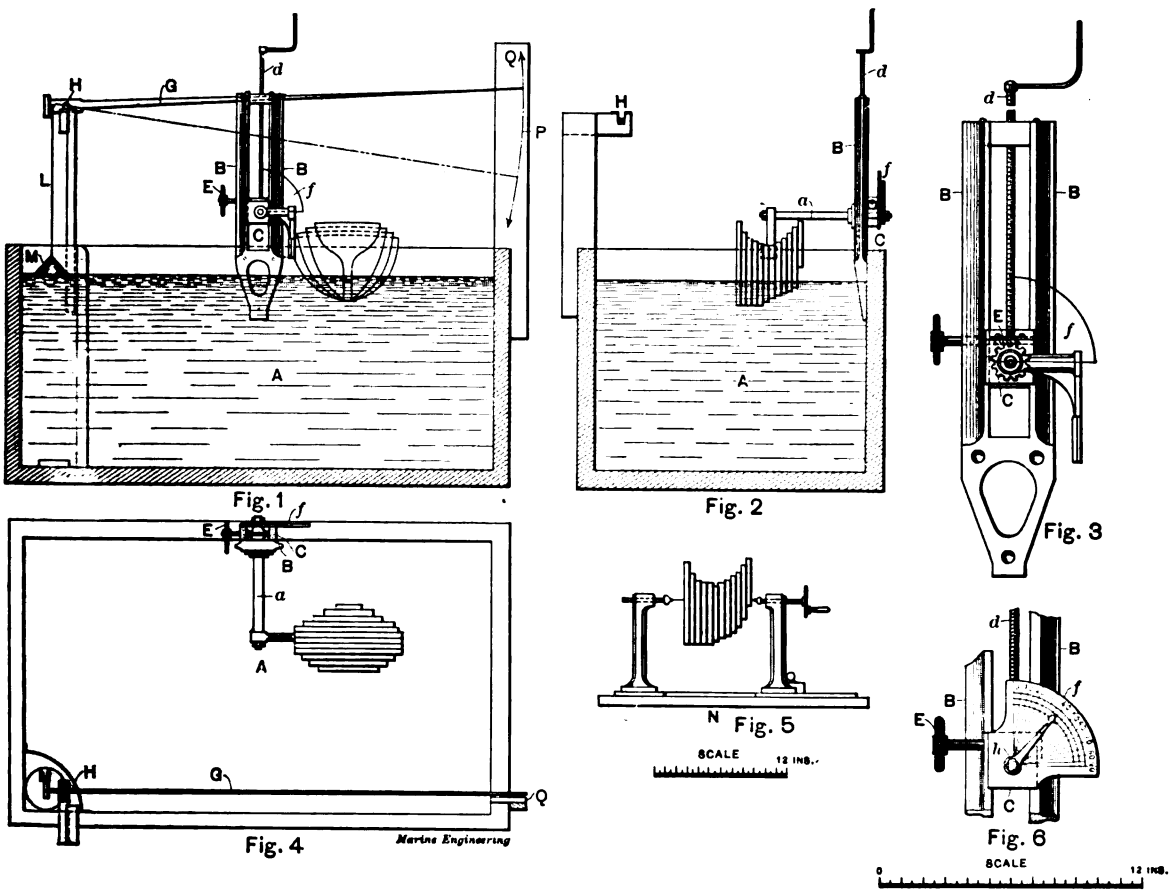
MECHANICAL METHOD OF ASCERTAINING STATICAL STABILITY OF SHIPS.*

BY A. G. RAMAGE.

The apparatus consists of a small tank A, holding water. The surface of the tank should be just sufficient to admit the wood sections of the ship, and permit them to be turned through the required angles. B—Figs. 1, 2, 3, 4, and 6—is a frame attached to the sides of the tank, guiding the sliding block C, which can be raised or lowered by the screw d; a—Figs. 2 and 4—is the arm to the outer part of which the sections are attached; a can be turned through any angle by the worm E—Figs. 3 and 6—the angle being indicated by the finger h on the plate f—Fig. 6; g—Figs. 1 and 4—is the indicating arm balanced on a knife edge H, and multiplying at its free point the vertical motion imparted to it by the float M through the rod L.

Sections of wood representing mean sections

*Read before the Institution of Naval Architects in London, April, 1897.



DIAGRAMS OF APPARATUS FOR ASCERTAINING STATICAL STABILITY OF SHIPS.

Digitized by Google

over the length each represents in its thickness are attached to the arm a, so that they are vertical when the finger points to zero, and so that the water-line to which the sections are to be immersed is parallel to the surface of the water. The sections are then screwed down into the water by the screw D till they are immersed to the required line. The float having risen owing to the displacement of the water, the indicating hand has moved through a large angle P.

When the water is still mark the position of the indicating hand on the board placed behind it, then raise the sections, and by the worm turn them round to the first angle of heel, say, 20 deg., screw them down till the indicating hand has swept through the same angle as for the upright displacement. They are then at the correct draught for the inclined position. Make a pencil mark on one or two points of the sections at the surface of the water, then lift the sections by the vertical motion. The sides of the tank having been made level to the surface of the water, lay a straight edge across the sides of the tank, and draw the water-line all round. When the inclined water-line has been drawn, unscrew the sections, and saw off the immersed part, balance it on the needle points, and ascertain its center of gravity or center of buoyancy, and measure with a scale its position from the center line and from water-line. Glue the sections together again, putting in a layer of wood to make up the saw rift, and repeat the operation for other angles. The points thus obtained having been set off on the body plan, with the center of buoyancy calculated for the upright position, give us the locus of centers of buoyancy, from which the righting arms may be measured.

I shall now deal with some of the objections which might be raised to the system, and also point out some of the difficulties which have to be overcome, and things to be guarded against. I do not think any one will object to the balancing of sections, because other systems which have gained considerable credit make use of these, and, though the homogeneity of the wood used is an essential, this can generally be secured by selecting clean yellow pine[1] for the purpose. The sections should be balanced first on the center line to prove that both sides are of equal weight. The water-absorbing powers of both sides should also be the same, or else the balancing should be delayed until the wood is dry. Yellow pine absorbs an amount of water, even after being coated with varnish, sufficient to sensibly affect the indicator hand. That is to say, the point of rest of the indicator will be higher after the sections have been lowered and raised than before the sections were put in. Care should therefore be taken that the indicating arm passes through the same arc as in the first instance.

The chief point we have to consider is the sensitiveness of the indicator. May not a layer sufficiently large to affect the accuracy of the result be too small to affect the indicator? Here is a sheet of tin of the size of the cross section at the water-line at 30 deg. inclination, which, on the scale to which the sections are made, represents about 3-8 in. If that sensibly affects the indicator, we may conclude that it is sensitive enough for all practical purposes. I put it in the water, and there is a sensible motion of the indicator. The difficulty of marking the sections correctly, owing to the viscosity of the fluid, is an objection that might be raised, but if some blue be mixed with the water there is not much difficulty in marking the true position of the water-line.

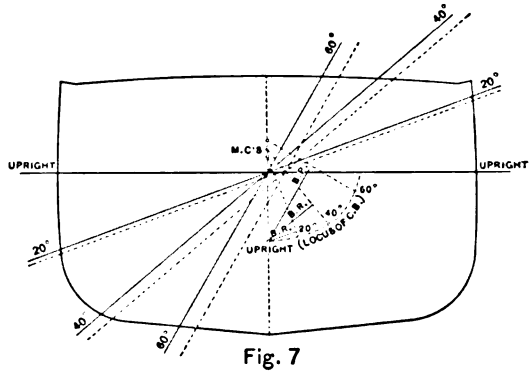


Fig. 7

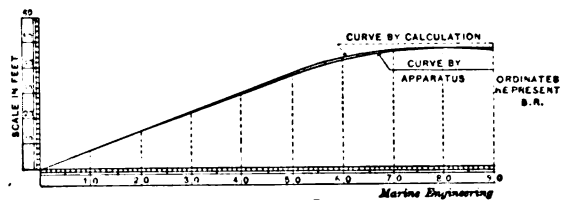
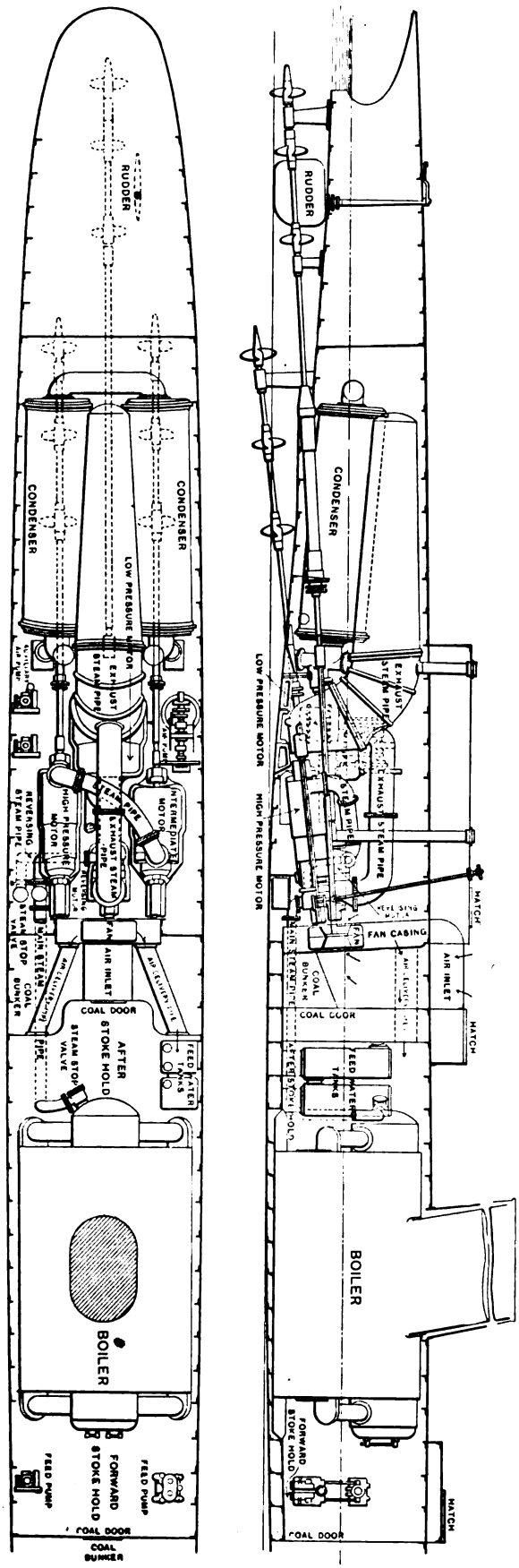


Fig. 8

The time necessary to make the sections and perform the operation is not great if we leave out the time which the glues take to harden when the parts are being reunited. A smart model maker will cut out the sections in about four hours, dipping, sawing, and balancing two hours, and gluing up, say two hours. The advantage lies in this, that the intelligent joiner or model maker can perform the whole operation, and he who is responsible can satisfy himself by a glance at the accuracy of the results, without wading through a labyrinth of figures. Pins can be driven into the sections to mark the position of the centers of buoyancy, the mean position of which should be set off on the midship section drawing. The indicator on my apparatus magnifies the vertical motion of the surface forty times. As to results, you will find on diagram, Fig. 8, curves showing the comparison of the result of calculation with the results given by the apparatus. The time necessary to get a sufficient number of points, say, at 20, 40, 60, and 90 deg., is probably the worst feature of the arrangement; but if three or four vessels are worked at the same time, which can be done, the time taken is much less than for the ordinary calculation. It is very important that the center of buoyancy for the upright position be very carefully calculated.

[1] Known in American practice as white pine.

Digitized by Google



SECTIONAL VIEWS OF THE TORPEDO BOAT TURBINIA FITTED WITH TURBINE ENGINES.

ROTARY AND RECIPROCATING ENGINES AS APPLIED TO SHIP PROPULSION.*

BY HON. CHARLES PARSONS.

The advantages of a rotary motor for the purpose of marine propulsion are manifest as regards a direct application of the force of the steam to the shaft to be driven, and a consequent saving of bulk, weight, friction, and wear. When such a motor is shown to be economical in steam consumption, and that the power delivered by the motor at a high speed of rotation can be economically transformed into thrust-power by the screw propeller, and that the whole of the machinery is simple and easy to work, the position of the rotary motor becomes well established as a rival of the reciprocating engine, provided there are no drawbacks to detract from the advantages which it manifestly possesses. Up to the present no such drawbacks have shown themselves, or seem likely to do so.

The compound steam turbine consists of a series of steam turbines set one after the other on the same axis, so that each turbine takes steam from the preceding one and passes it on to the succeeding one. Each turbine of the set consists of a ring of fixed blades called guides fixed to the casing, and also of a ring of moving blades attached to the shaft. The steam from the steam pipe entering all round the shaft passes through the first set of guides, then through the first set of moving blades, then through the second set of guides, then through a second set of moving blades, and so on through the complete turbine motor. The blades are carefully shaped, as in water turbines, and the action of the steam in each turbine of the set is similar to that of water in the water turbine.

Steam is, however, an expansive fluid, and though its action in each individual turbine is approximately as if the fluid was inelastic, yet a small increment of volume takes place at each passage through the blades, and the expansion going on at something like geometric ratio at each of the numerous successive turbines soon assumes large proportions. Ratios of expansion of fifty up to one hundred or even two hundredfold are common in one single compound turbine of the condensing type; a notable feature in turbine practice being that high expansion ratios and very large volumes can be economically dealt with without necessarily increasing the size and weight of the engine to any large extent, or, what is perhaps more important and gives the turbine a special advantage over ordinary engines, is that practically no increase in frictional resistances is incurred by arranging for the extra expansion, and exceptional economy in steam is thereby realized. The high speed of revolution diminishes not only the weight of the engines themselves in proportion to a given horse power, but also of the shafting,

*Read before the Institution of Civil Engineers, London, May, 1897.

Digitized by Google

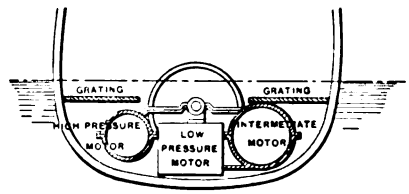
propellers, and supports, as well as of the hull. The total weight of machinery in vessels of the torpedo boat or torpedo boat destroyer class on the turbine system, will probably not exceed one-third that of ordinary engines of the same power. The consumption of steam on recent trials on the Turbinia has been shown not to exceed 14 1-2 lbs. per indicated horse power at full load, or considerably less than that of similar engines of the reciprocating class, so that the size and weight of the boilers, and also the amount of coal carried can be considerably reduced, and consequently the total displacement of the vessel to be propelled will be largely reduced, so that with a given horse power much greater speeds may be attained; or, on the other hand, heavier cargoes may be carried with a given consumption of coal per knot. To these advantages must be added that the space occupied by the turbines is very much less than that occupied by ordinary engines, thus increasing the capacity of the vessel, and also that the turbine machinery being placed near the bottom of the vessel, the center of gravity is thereby lowered, and the stability of the vessel increased. Also, owing to their position—and even in the Turbinia with only 3 ft. draught—they lie almost wholly below the water line—a matter of considerable importance in war vessels.

The almost total absence of vibration, owing to there being no reciprocating parts, admits of a diminution in the weight of the hull, and in fast vessels admits of a degree of comfort not hitherto attainable, and also in the case of warships, enables guns and torpedoes to be worked with ease and accuracy. Another feature is that, owing to the reduced size and weight of the shafts and propellers, this not only facilitates duplication and repair, and enables spare parts to be carried on board the vessel to an extent not hitherto practicable; but also, owing to the smaller diameter of the propellers, it admits of screw-propelled vessels being used for navigating shallower waters.

To summarize, the merits of the turbine system applied to marine propulsion appear to be:—(1) Greatly increased speed, owing to diminution of weight and smaller steam consumption; (2) increased carrying power of vessel; (3) increased economy in coal consumption; (4) increased facilities for navigating shallow waters; (5) increased stability of vessel; (6) reduced weight of machinery; (7) reduced cost of attendance on machinery; (8) reduced size and weight of screw propellers and shafting; (9) absence of vibration; (10) lowered center of gravity of machinery, and reduced risk in time of war.

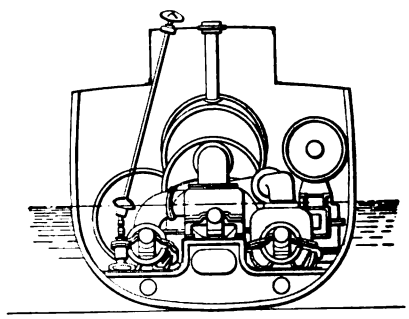
The first ship fitted with turbine engines has been the Turbinia. She is 100 ft. in length, 9 ft. beam, 3 ft. draught amidships, and 44 1-2 tons displacement. She has three screw shafts, each directly driven by a compound steam turbine of the parallel flow type. The three turbines are in series, and the steam is expanded—at full power—from a pressure of 170 lb. absolute, at which it reaches the motor, to a pressure of 1 lb. absolute, at which it is condensed. The shafts are slightly inclined, and each carries three screws, making nine in all. The screws have a diameter of 18 in., and when running at full speed they make 2,200 revolutions per minute. Steam is supplied from a water-tube boiler, and the draught is forced by a fan, mounted on a prolongation of the low-pressure motor shaft, the advantage of this arrangement being that the draught is increased as the demand for steam increases, and also that the power to drive the fan is obtained directly from the main engines.

Up to the present the maximum mean speed attained has been 32 3-4 knots, as the mean of two consecutive runs on the measured mile. These runs were made after about four hours' steaming at other speeds, and the boat on the



SECTION THROUGH MOTORS.

day of the trials had been fifteen days in the water. It is anticipated that on subsequent trials, after some alterations to the steam pipe, still higher mean speeds will be obtained. As it stands, however, the indicated horse power realized is 2,100 and the consumption of feed water per indicated horse power hour 14 1-2 lb., and the speed the fastest of any vessel, irrespective of size. The weight of the main engines is 3 tons 13 cwt. Total weight of machinery, including turbines and auxiliary engines, condenser and boiler, the propellers and shafts, the tanks and the water in boiler and hot well, 22 tons. Thus nearly 100 horse power is developed per ton of ma-


SECTION THROUGH ENGINE ROOM LOOKING AFT

chinery, and nearly 50 horse power per ton of displacement of boat.

In the Turbinia the stresses on the boiler and machinery are, as far as possible, according to the Board of Trade rules, and the scantlings of the hull are heavy for a boat of her size and class. It is believed that when boats of 200 ft. in length and upwards are fitted with compound turbine motors, speeds of 35 to 40 knots may be easily obtained in vessels of the destroyer class.

Digitized by Google

ON USE OF WATER-TUBE BOILERS IN THE MERCANTILE MARINE.*—1.

BY A. E. SEATON, M.C.I.N.A.

The resurrection and revival of the water-tube boiler and its successful employment for naval purposes has naturally caused the question to be asked on all sides, "Cannot such boilers be used with advantage in the mercantile marine?" and, as may be supposed, the replies of engineers differ very largely on the subject, varying between the extreme opinions that there is nothing to hinder their immediate adoption, and that such boilers are not or never can be fit for mercantile steamships. The controversy, both in political and professional circles, has practically revolved round one particular form of water-tube boiler, so that the general merits of the case have been confused, and in many instances entirely lost sight of.

The water-tube boiler first appeared in America in the very early days of this century, long before Queen Victoria ascended the British throne. The object of Colonel Taylor, in 1807, was to substitute for the heavy, roomy, and somewhat inefficient Cornish boiler a generator more suitable to the exigencies of shipboard, and that after experience with the paddle steamer Clermont on the Hudson. It will thus be seen that at the outset the distinguishing features of a water-tube boiler, viz., light weight and small space occupied, operated to cause it to be proposed in the mercantile marine of America. Many efforts have since been made in America to employ a water-tube boiler of some kind or other in mercantile ships, so that to-day the engineers of the United States are in a much more receptive mood for the adoption of the water-tube boiler than are the engineers of this country, where hitherto the attempts to use that form of boiler at sea have been few and far between, and mostly attended with ill-success. The possibilities of the water-tube system have not, however, either in Great Britain or elsewhere, been exhausted; and although there are at the present time many types in successful use, none altogether fulfil the necessary conditions for the best form of water-tube boiler.

Considering the ideal water-tube boiler to consist altogether of cylindrical components, with either spherical ends or ends of such a form as to require no staying, and subject only to internal pressure, it needs little demonstration to show that such a boiler must be lighter, stronger, and more capable of withstanding rough usage than a boiler which is a combination of cylindrical components—a large portion of which is subject to external pressure—rectangular boxes, flat ends, etc.; and therefore it will be assumed that it is in itself lighter than the Scotch boiler, pressure for pressure, and especially so for high pressures; that it contains less weight of water than its rival; that it can be designed to occupy as little or even less space than the Scotch boiler; and that steam can be got up in it in half an hour as against four to six hours with the Scotch boiler. All these assumptions are, however, borne out by recent practice. In the British Navy, experiments with both the Belleville[1] and Thornycroft boilers have shown that the type can be worked as economically as to fuel as the Scotch boiler, and that the amount of coal required to get up steam is considerably less. There is indeed no prima facie reason why a water-tube boiler, properly designed and properly worked, should not be capable of evaporating as much water from a pound of fuel as the ordinary boiler can.

The enduring powers of the water-tube boiler have not yet been demonstrated, and as that is a question of cost, it necessarily has a very important bearing in determining their use in commercial steamships. But here, again, there are no prima facie reasons why a water-tube boiler should not last as long as any other boiler; indeed there are many reasons why it should last longer, not the least of which is the fact that it is not subject to distress of itself as a whole, or of any of its more important parts, on rapidly raising steam, or on rapidly cooling down, whereas a Scotch boiler is very materially affected by these circumstances, and the length of its life is probably in the inverse ratio to the number of times steam is raised in it. It must, however, be understood that this statement does not imply that any of the existing boilers comply with the ideal conditions, and consequently their lasting powers may possibly be not so great as that of the Scotch boiler; but the evidence of the boilers that have been fitted into ships of the mercantile marine points in the direction of equal or greater longevity for the water-tube boiler.

The prime cost of the Belleville boiler is undoubtedly very much greater than that of the best cylindrical boilers, and it is probable that every kind of water-tube boiler in which so much screwing and so much accuracy of fitting is involved, and for which so many special fittings are required, will always exceed the cost of the old type of boiler; but the Babcock & Wilcox boiler, and boilers of the type in which the tubes are simply expanded in place, and for which no special appliances are necessary either for circulation or for fuel burning, cost little or no more than the ordinary boiler. Experience with both the Belleville and the Babcock boiler has shown that defects and mishaps may be remedied at sea by the vessel's own staff, and that mishaps of a more serious nature can, at comparatively slight expense and in a short time, be effected in port. On the other hand, the mishaps to the tank boiler, especially when it is getting old, are much more serious, repairs can very seldom be executed

* Read before Institution of Civil Engineers, London, May, 1897.

[1] 10.3 lb. of water per lb. of coal—from and at 212 deg.—has been evaporated from the boilers of H. M. S. Furious when burning over 30 lb. of coal per square foot of grate.

Digitized by Google

at sea, and when done in port necessitate a considerable expenditure of time as well as money. With existing designs of water-tube boiler, a little more care in stoking is necessary, especially if the best results from the fuel are required; but there is nothing so serious as to prevent the ordinary everyday marine fireman from being educated in a few hours to manage the fires of a water-tube boiler as well as he manages those of the Scotch boiler. From the conditions of employment in the mercantile marine this is likely for some time to be a difficulty; still it is not an insuperable one, and, if ships' engineers will take the proper precautions, need not be one of long duration in any ship.

The ideal boiler referred to—or perhaps, preferably the boiler of the future, because it is not likely that any boiler will ever quite fulfil every requirement of an ideal boiler—must have a rapid, uniform, and definite circulation, the upcast tubes should be very considerably inclined from the horizontal, and the nearer they are to the vertical position the better; they may be large or small according to fancy or circumstances; they should be capable of easy examination, and therefore must be straight or nearly so, and their arrangement should be such that any one of them may be easily drawn and replaced; the downcast pipes, or those from the steam drum to the water pockets, should be as direct as possible and of considerable size, and at or near their bottoms there should be a receptacle with no circulation—in other words, a dead end, so that solid matter can, by gravity, be separated from the liquid; the fireplace and its surroundings should be of such size and nature as to allow of the proper combustion of the fuel and its effluent gases, while the general structure of the boiler should be such as to enable it to bear sudden expansion and contraction with impunity, and the whole of the surface exposed to flame and hot gases should be accessible for cleaning. If these conditions are fulfilled, there is no absolute necessity for using pure fresh water, inasmuch as the rapidity of flow will prevent deposition on the upcast pipes by the mechanical scour of the water; the dead ends permit of the deposit at a safe place, and if there is any deposit on the downcast pipes, they—being of considerable size and easy of access—can be cleaned when opportunity serves and if necessary, would go for a considerable period without cleaning. The absence of these conditions in the boilers of the Propontis and other ships which have not been successes, has no doubt conduced to their failure, and although to-day the means of obtaining fresh water by evaporators, etc., permits of the use of pure water in boilers, and has to a large extent been the means of the admission of these boilers on shipboard, that it is really no more a necessity with the type when properly designed than with the Scotch boiler.

ORIGIN AND DEVELOPMENT OF THE FERRY-BOAT.—3.

BY EDWIN A. STEVENS.

While the detail of construction of the older boats possessed historical interest, the means employed by various designers to meet the conditions of the problem of ferryboat construction can best be exemplified by descriptions of boats now in actual service.

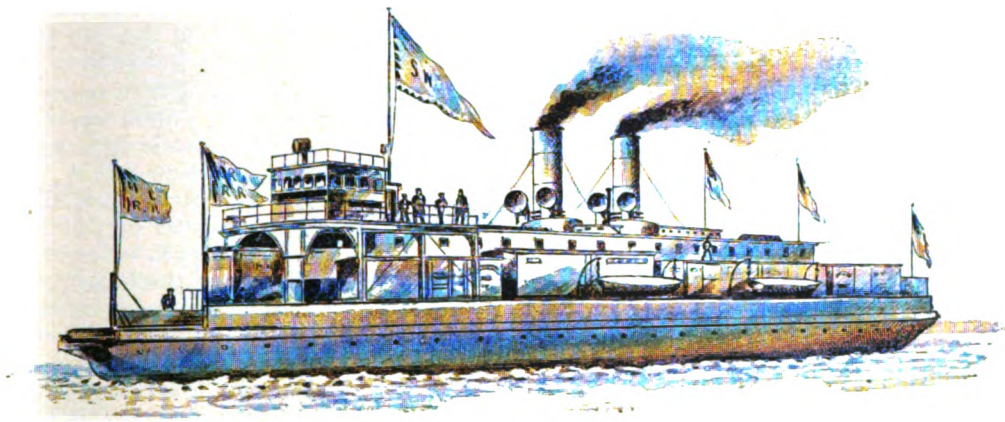
There are now operating on the same route, side by side, driven by practically the same engines, wooden boats of twenty or twenty-five years of age, and iron and steel boats. The models have not varied greatly as a consequence of the change in material, excepting possibly on the Hoboken ferry. On that route the wooden boats were built with midship section of a triangle with its apex cut off, the frames being straight and the floor narrow, but perfectly flat. On other routes a vertical side and a nearly flat bottom were the universal characteristics. The propelling machinery of the side wheel boat usually consists of a beam engine, single expansion type, with poppet valves generally actuated by Stevens cut off. The diameter of the cylinders varies from 42 in. to about 50 in.; the stroke in late years has been rarely less than 10 ft. Boilers of various types are used, some of them closely resembling the straight through design known as the Admiralty boiler, in others the double return drop flues are used; a single boiler is the rule. Condensation is obtained by a jet, the air pump being driven from the main beam. Steam pressure is carried at about 30 lbs., though in a few boats the pressure allowed by the Inspectors reaches some 10 or 15 lbs. above that figure.

The displacement of the Orange and Montclair, of the Hoboken ferry, taken as typical of this type of boat, is about 800 tons; their length on water line is 217 ft.; the beam on the water line is 32 ft. The cabins are heated by steam in radiators placed under the inboard seats on the main deck. Ventilation is generally secured by outlets through the upper deck. This system can hardly be said to give satisfactory results in Winter, when the doors are closed as much as possible. The passage connecting the cabins at the ends of the boats, which is rendered necessary by the presence of the paddle boxes, practically makes each cabin a separate compartment for the purposes of ventilation; the opening of the doors, therefore, at both ends of the boats, even if simultaneous, does not ensure enough circulation to entirely remove foul air. The Orange and Montclair were designed by F. B. Stevens, and were built in 1886; the hulls by T. S. Marvel & Co., of Newburgh; the engines by the W. & A. Fletcher Company, of Hoboken, N. J. These boats when new represented the best and most advanced practice of their day.

A number of such vessels have been double-decked, and in this form have performed satisfactory service. Where good results have not been

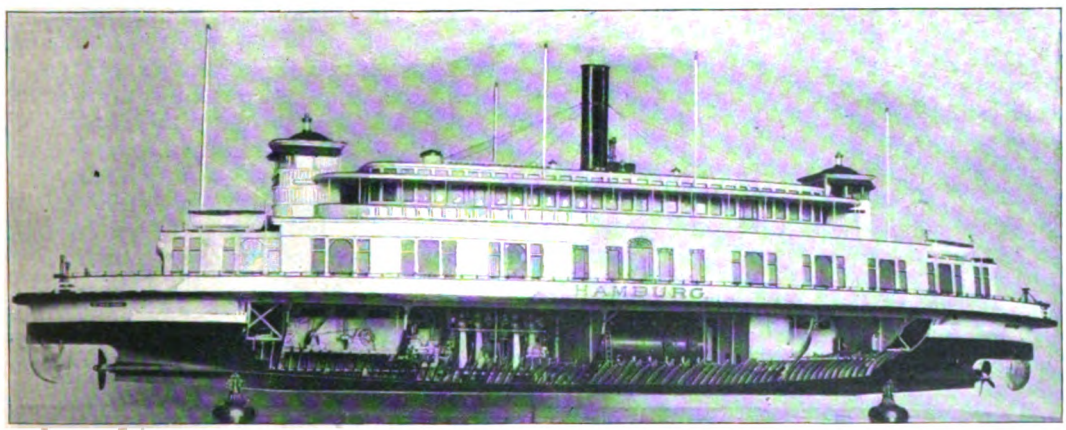
Digitized by Google

attained, it has been due to lack of stability, power, or structural strength of hull. The most highly developed form of side wheel boats in this country have been the Garret and Wiman, of the Staten Island route. These boats are 235 ft. in length, and 32 ft. beam on the water line. They are



MACKINAC, MICH., TRANSFER STEAMER ST. IGNACE.

driven by two cylinder compound engines, 39 3-8 in. and 70 in. dia. by 60 in. stroke, of the inclined type, resembling closely some of the English designs for side wheel vessels. There are two double ended Scotch boilers, with a heating surface of some 5,300 sq. ft., and 170 ft. grate surface, designed for 110 lbs. pressure. The paddle wheels are of the feathering type, 17 ft. dia. The engines are run at an average of about 40 revolutions per minute. Owing to the fact that the dip of the wheels is greater than designed, the adjustment of the eccentrics governing the angle of the buckets has been so arranged that the full advantage of the feathering principle is not obtained.



DOUBLE-SCREW FERRYBOAT HAMBURG OF HOBOKEN FERRY.

These boats came out in 1888. They were built of steel by the Columbian Iron Works, of Baltimore.

The Bergen of the Hoboken ferry was built in 1888 by T. S. Marvel & Co., of Newburgh. Its engines are by the Delamater Iron Works, of New York. Until this year she has had but a single deck. Her length is 200 ft.; her beam at the water line 32 ft., with about 17 ft. depth of hold. Her engines are triple expansion, cylinders 18 1-2, 26, and 42 in. dia. and 24 in. stroke. She has two boilers, of what is known as the Admiralty, or gun-boat type, with straight through draft, designed to work at 160 lbs. pressure. The Bergen's air pump is operated by levers from a low pressure crosshead, but the circulating pump and feed pump are independent. The objection, alluded to in a previous article, to the use of an air pump directly from the main engine of a screw vessel, has been justified in the case of the Bergen. Although its attachment to the main engine was of excellent design, and no fault could be found with the workmanship, the amount of care required to prevent undue loss of motion has impressed those responsible for her operation with the undesirability of this arrangement. The longitudinal section of the Bergen, shown herewith, gives a clear idea of her general arrangement.

Digitized by Google

She was the first of the screw passenger ferryboats successfully operated in this country. There had been previous boats built from designs of Livingston Brady, and alluded to in a previous article, though since the date of publication some doubt has been raised as to whether these boats were even tried in ferry service. While the Bergen was being designed, W. S. Cowles, who, to a considerable experience in ferry service, added the advantages of a thorough mechanical education, published a paper before the American Society of Mechanical Engineers, at its Boston meeting, in 1885,[1] in which he suggested a vessel designed especially for the Staten Island route. Apart from some details as to the arrangement of gangways and smokestacks, the system of working the rudders, and the protection afforded them from ice, their design closely resembles the Bergen. The greatest difference is, that in Mr. Cowles' design, two universal joints were suggested, one placed at each end of the engine. This would have allowed for the alteration in shape undergone by all vessels for change in their loads. It also allowed the midship section to be made considerably shallower, thus reducing the wetted surface.

The Oxton, a boat built in the eighties for service between Liverpool and Birkenhead, and driven by four screws, two at each end, had used continuous rigid shafts from screw to screw. The example set by her designer, Simons, of Renfrew, was followed in the Bergen, and in the other American boats that have followed her.

Measurements were taken on the Bergen to determine the deviation due to the variation in load. These deviations were found to be small enough to be negligible. Exposed as ferryboats are, continuously to collision, experience has shown that the guards overhanging the hull afford great protection, but there have been cases of serious damage to the hull, and, while this has been mainly at the ends, the increased risk due to the use of steel hulls rendered some further protection amidships desirable. The natural method of guarding against accidents at the ends is by the use of collision bulkheads; but, in order to secure safety against accidents in the region of the water line, toward the middle of the vessel, longitudinal bulkheads were introduced, running from one collision bulkhead to the other. These bulkheads form longitudinal girders of great efficiency, materially stiffening the hull.

A short time previous to building the Bergen, the St. Ignace was designed and built by the Detroit Dry Dock Company for service as a car ferry on the Straits of Mackinaw. This branch of ferrying has of late years assumed great importance upon the Lakes. Although, at first, the apparent incongruity of carrying so large a non-paying load, in proportion to the paid, appeared to limit its usefulness.

The St. Ignace, a sketch of which is shown, was especially designed for ice breaking, and thus may be viewed as a precursor of the Pere Marquette, illustrated and fully described in the May number of Marine Engineering. The main differences, apart from the accidental one of superstructure, and the use of steel in the latter vessel for material instead of wood, lies in the fact that the St. Ignace has two sets of propelling machinery, the larger one operating a screw 16 ft. dia. at the stern, the smaller one of 12 ft. at the bow, the engines and screws being entirely independent.

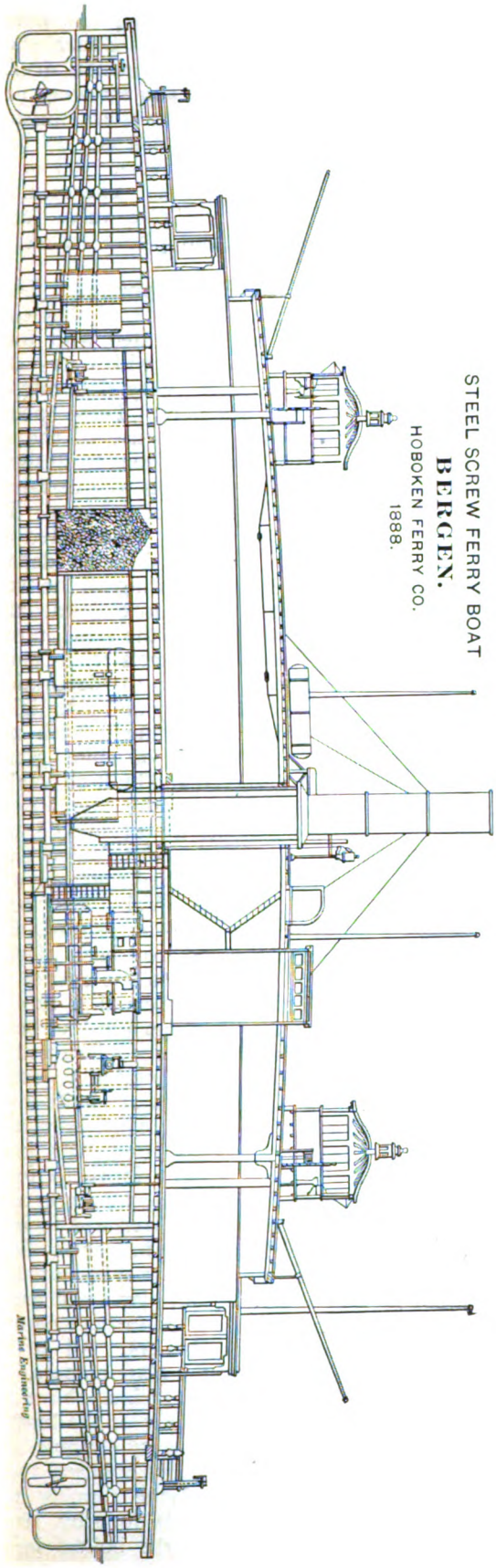
The second of the passenger screw ferryboats to appear in New York waters was the John G. McCullough, built by Neafie & Levy, of Philadelphia, connecting the New Jersey terminus of the Erie Railroad with New York city; she entered the service in the latter part of 1891. This vessel is 214 ft. over all, 43 ft. beam over the hull, and 62 ft. over all. She is built of steel, with two longitudinal and four athwartship bulkheads. The machinery consists of a compound engine, with cylinders 26 and 50 in. dia. by 30 in. stroke; two Scotch boilers, and a surface condenser, and independent circulating air and feed pump. Her length is slightly less than that of the Orange, above described, but slightly greater than that of the Bergen. The beam in all these boats is exactly the same.

It is curious to note, however, the difference in seating capacity. The Orange in her single deck form provided seats for 254 passengers, the Bergen for 296, and the McCullough for 328.

Toward the close of 1891 and beginning of 1892 four more screw boats were put in service on the Hudson River. They were the Cincinnati and Washington, of the Pennsylvania Railroad, and the Hamburg and Bremen, of the Hoboken ferries. The latter boats were built from the same design. They are 217 ft. long, 40 ft. in beam over the hull, about 36 ft. beam at the water line, and 62 ft. beam over the guards. Their arrangement is very clearly shown in the photograph of a model of the Hamburg. As will be seen in the illustration, the plating is removed from a little beyond the collision bulkheads at each end of the boat, and the frames are stopped short at the turn of the bilge. On the left of the illustration, just beyond the collision bulkhead, may be seen the diagonals of the truss, which extends the longitudinal bulkhead until its line intersects the skin of the vessel. Indistinctly shown behind these diagonals is the steering engine, which is of the Williamson type. Within the main body of the vessel, just aft of the collision compartment, is the electric light engine and dynamo, while on the opposite side, and removed for the purpose of clearness, is placed a ventilating engine and its coil of heating pipe. Next to the electric light engine is a combined air and circulating pump, designed and built by the Geo. F. Blake Co. Next again comes the main engines, with four cylinders, two of 20 and two of 36 in. dia. by 28 in. stroke. Against the midship bulkhead, but still in the engine room, is seen the donkey boiler, a small upright boiler of the ordinary type. Be-

[1] Vol. vii, p. 190.

Digitized by Google



STEEL SCREW FERRY BOAT
BERGEN.
HOBOKEN FERRY CO.
1888.

yond the midship bulkhead are the main boilers and coal bunker, then a vacant space intervening before one reaches the forward collision bulkhead, beyond which is another steering engine. In the ends, out of sight in the model, are the water tanks. The photograph shows clearly the longitudinal bulkhead, and its method of construction, with openings close to the deck for ventilation of the wing compartments. The shaft may be traced under the engine room, while the propellers and rudder are in clear view.

The cut of the Bergen shows the difference of the suspension of the rudder in these two boats. On the Hoboken ferry it has been usual to use balanced rudders hung by the head only. On other routes the rudders have usually been hung by pintals.

In other screw boats there is usually a stern post which affords the propeller some protection, but at the cost of a loss in efficiency. At one time the Hoboken boats suffered from broken propellers, and the risk of leaving them without protection should be considered. The greatest dangers are old piles and other water-logged timber, which have a perverse habit of settling down for a rest in ferry slips. The breakage by ice, so formidable to side wheels, is not to be feared with propellers.

An unofficial trial trip of the large steam launch Ellide, built at Ayer's shipyard in Nyack from the designs of Charles D. Mosher was carried out June 18. This boat is 80 ft. long, 8 ft. 4 in. beam, and has a draught of 3 ft. 6 in. According to the newspaper reports, a speed equivalent to 31.9 knots was attained on the measured mile, not allowing for tidal corrections, and it is said that this would have been exceeded had not the engineer misunderstood the slowing down signal. The boat is fitted with a quadruple expansion engine, with cylinders 9 in., 13 in., 18 in., and 24 in., with 10 in. stroke. With 250 lbs. pressure in the boiler, which is of the Mosher water-tube type, and the throttle valve partially closed, the engines are credited with 650 revolutions. The trial was witnessed by the owner, E. Burgess Warren, of Philadelphia, and Harrison B. Moore and Francis Magoun, of New York. The boat is composite build with steel frames and mahogany planking. The hull is divided into five water tight compartments. The boat is described as having a forward deck 13 ft. long, aft of which is a cockpit 13 ft. long, fitted with the navigating apparatus, with seats along the sides and lockers underneath. Next aft is an ice chest and china closet on the port side, and toilet conveniences on the starboard side. Further aft are the machinery spaces, and then a dining room 18 ft. long, fitted with side seats and lockers, an extension table, and pantry and buffet. The after deck is about 12 ft. long. The Ellide has a large awning running almost the entire length, a single brass smoke stack, and carries a 13 ft. boat.

Digitized by Google

NOTES ON BRITISH SHIPYARDS AND METHODS OF CONSTRUCTION.*

BY WALTER MILLER.

In this paper the author gives his impressions of many of the large marine engineering establishments in the United Kingdom, which he visited not long ago. As these contain many valuable hints and ideas, the following extracts relating to the better known yards are given:

A. & J. Inglis, Engineers and Shipbuilders, Glasgow. The engine shops rather old style. Round bottomed bushes are used in the main journals of the bed plates with flat tops, wrought iron binder plates and bolts. Bushes filled with white metal. Top ends of eccentric rods forged solid, then are bored for the link pin, bushes drilled for the bolts and are then cut apart. Cranks built up in three sections; the separate parts are put together by shrinkage, gas being used to heat the parts. The crank pins and coupling shafts are farther secured on the crank arms by round steel keys. The bed plates of the engines are planed off on the bottom. In machine shop tools, the large upright planer, horizontal boring and radial drills are prominent. The shipbuilding yard is equipped with hydraulic riveters. Stationary oil furnace is used to heat the rivets, steam traveling cranes handle the material about the yard. The riveting up of the reverse frames, floor plates and beams, is done very rapidly. The frames are all faired up on the scrive board, the floor plates laid in place, and the holes marked off. The frames, together with the reverse bar, floor plate and beam, are all re-assembled after punching, bolted up fair, then taken by the steam crane to the hydraulic riveter, which is swung on a gib crane, having a radius long enough to reach all the rivet holes in the assembled frames. The rivet boy takes the rivets out of the furnace by the shovelful, and with a light pair of tongs drops them in the holes, and the riveter follows up and completes the work.

J. &. G. Thompson Co., Lim., Clydebank, Glasgow. These works are very large and shops modern; completed with overhead cranes and new tools. Large vertical planers, horizontal drilling and boring machines. The engines are erected in pits. Large Government contracts on hand. In the boiler shops on all the inside work on the Scotch boiler, the riveting is driven countersunk; the heads of the rivets are nearly flush. Front and back head flanges turned in; the last head riveted by hand. The rivet holes are countersunk, the rivets driven full and finished by a set. Vertical rolls are used for rolling the boiler shells.

The Fairfield Ship and Engine Co., Lim., Govan, near Glasgow. These works are very large; the general plan of the shops is a series of bays, and each bay is served with one and two overhead cranes. All of the shops are complete with new and modern tools. In the machine shops large vertical planers, horizontal drilling and boring machines are used extensively. Boiler shops have vertical rolls and large horizontal drilling machines for drilling, tapping and screwing in of stay-bolts. Tops of cylinder heads are finished, false covers of rolled steel plates cut on band saws to fit heads and chest covers. All of the large engines are erected in pits. The cylinders are fitted with liners and a false valve faced. Double and triple slides and piston valves are used.

Wm. Denny Bros. & Co., Shipbuilders, Dumbarton, Scotland. The shipyards of this company are very large and well fitted with tools. Experimental tank is complete with every convenience for testing models. Very elaborate experiments are carried out here. These people attach great importance to the use of the experimental tank, as it enabled them to design a vessel to have a speed of 21 knots to a certainty; this was an advance in speed of 6 knots. The fastest vessel they had previously constructed had a speed of 15 knots. All the different departments in the yard are fitted for doing all the work necessary to finish the vessel entire. Seasoning of lumber, sawing and dressing the same, finishing of hard woods, carvings, upholstering, painting and decorating, etc., even to the decorations on the stained glass used for sky and side lights. The machine shop is well arranged with new erecting shop, with side walls of white glazed brick. Engines are designed and built on Walter Brock's patent plan; high pressure cylinder forward; low pressure cylinder in the middle, and intermediate pressure cylinder aft. Valve chest facing port side. Cylinders bolted together with receiver spaces on same side. Valve gear combination of single eccentric and crosshead, with levers and curved links pivoted on back of condenser. Eccentrics connected to one end of the curved link, which has a throw equal to the extreme travel of the valves, and lap and lead being obtained by a combination of lever fulcrumed on radius rod at one end and connected to crosshead at the other. Crank shafts are built up in the usual way and are coupled by taper bolts with round heads. The bolts are fitted with brass washers under heads of bolts. Have to forge all bolts and nuts. The boiler shops are open on the front side, fitted with overhead cranes. Heating furnace has floor plates in front of furnace served with small steam hammer mounted on gib crane, for straightening out plates and flange work. They do not bore out the furnace mouths on the front heads of the boilers. All of the flanges are trimmed off on the plate planers.

Harland & Wolff, Belfast, Ireland, have the largest and most complete works of the kind in the United Kingdom. Shipyard, engine and boiler plant equipped with most modern tools. Boiler work good. All of the tapping and screwing in of the stay bolts is done by large, horizontal drilling machines, the boilers being

* From a paper read before Civil Engineers Club of Cleveland, May, 1897.

Digitized by Google

brought up and lined in front of the machines. Flush riveting is done on all inside work and on the front head in way of the breachings and around furnace mouths. All holes drilled, flanges planed, screw stays full size of bar, plain tubes not beaded over, and nuts on stay tubes. All of the flanges on the boiler heads are turned inward. The back head rivets are driven by hand. All rivets driven by hand are countersunk. Cylinders all have liners and false valve faces. Piston valves are used on high pressure cylinders only. Excepting in small sizes the cylinders are cast separate. The eccentric yokes are of wrought iron, finished and lined with white metal. Crank shafts are built up in separate parts in the usual way.

Messrs. Maudsley, Sons & Field's (Lambeth, London) shops are old but famous. For many years they have been large contractors for engines and boilers for the British Navy. Machinery that is built for the Navy is usually of their own design. This company manufactures the Belleville boiler. The work done on these Belleville boilers is quite similar to what was done on the Belleville boilers of the S.S. "Northwest and Northland," excepting that the tubes are larger in diameter, and the elements are longer and higher, thus making each boiler of greater power than those built here. The Belleville boilers, made at these works for the Navy, have the ends of the tubes upset before the thread is cut, so that the tubes have their full section after the threads are cut. All of the castings are of steel, including the heads of the steam separator, mud collector, and feed water regulator. The return tubes are used on each of these boilers, which improves the circulation very much. Had some very fine examples of marine engines in hand. Cylinders fitted with liners and steam jacketed. Piston valves on high pressure cylinder, double ported slide, balance valves on the intermediate and low pressure cylinders. As designed, each engine is separate and the cylinders are supported on four cast iron columns, which form the guides as well. Each pair of columns are connected athwartships below the guide by a wrought iron girt. Tie rods connect cylinders about half-way up. Engines of this design take up more room, fore and aft, than usual, but gives ample room below, and it makes them very accessible and easy to get at. The engine room floor plates are level with the journal caps, thus placing the crank shaft well below the floor plates. The stern tube bushes are all planed for the wood filling. This work is done with a round bar on the planer.

Humphrey & Tennant, Depford, London. Builders of marine engines and boilers. They build largely for the Navy. The boiler work is very fine. The engines have steel castings for the columns and bed plates. Round bottomed brass bushes are used on the lower side of the main journals in the bed plates. All the bushes are filled with white metal. Cylinders are cast separate, but are connected with tie rods. The cylinders and columns are thoroughly braced. Round steel columns in front. Link motion, single bar. Eccentric rods take hold of the bar at end. The end of eccentric rod is outside of link block. Suspending rod takes hold of go-ahead eccentric rod pins, which makes a very short suspension rod. Eccentric straps wrought iron, lined with brass and white metal. The valve stem guide is fitted on the after side of gear, and is open on the forward side. All cylinders, piston heads, and chest covers are steel castings. Columns have slipper guides. The large planers in the machine shops plane both ways, using a revolving tool holder, tool turned by cord from belt shifter. In boiler shop back head flange turned in and rivets driven by hand. In all rivets that are driven by hand the holes are countersunk. Through braces upset at ends. Thin nuts on the inside and full sized nuts on the outside.

John Thornycroft & Co., Chiswick, London. Plant designed for small work only. Engines are built of very high speed and peculiar design. The cylinders are arranged at an angle overlapping each other, thus enabling the centers of each cylinder to be placed closely together. Each pair of cranks are nearly at an angle of 180 deg., with two journals to two cranks, making only six bearings in each bed plate. There are four steam cylinders; one high, one intermediate, and two low pressure. One piston valve and three double ported balance slide valves are used. The intermediate and two low pressure cylinders are of the same size, with the pistons all of the same weight. The engines are nicely balanced, but small ratio between cylinders. Economy not so much an object as a high speed. Link motion is fitted to all the valves, the high pressure valve being adjustable only. All around steam and hand reverse gearing used. The exhaust is taken out through the back of the slide valves, thus simplifying the cylinder castings.

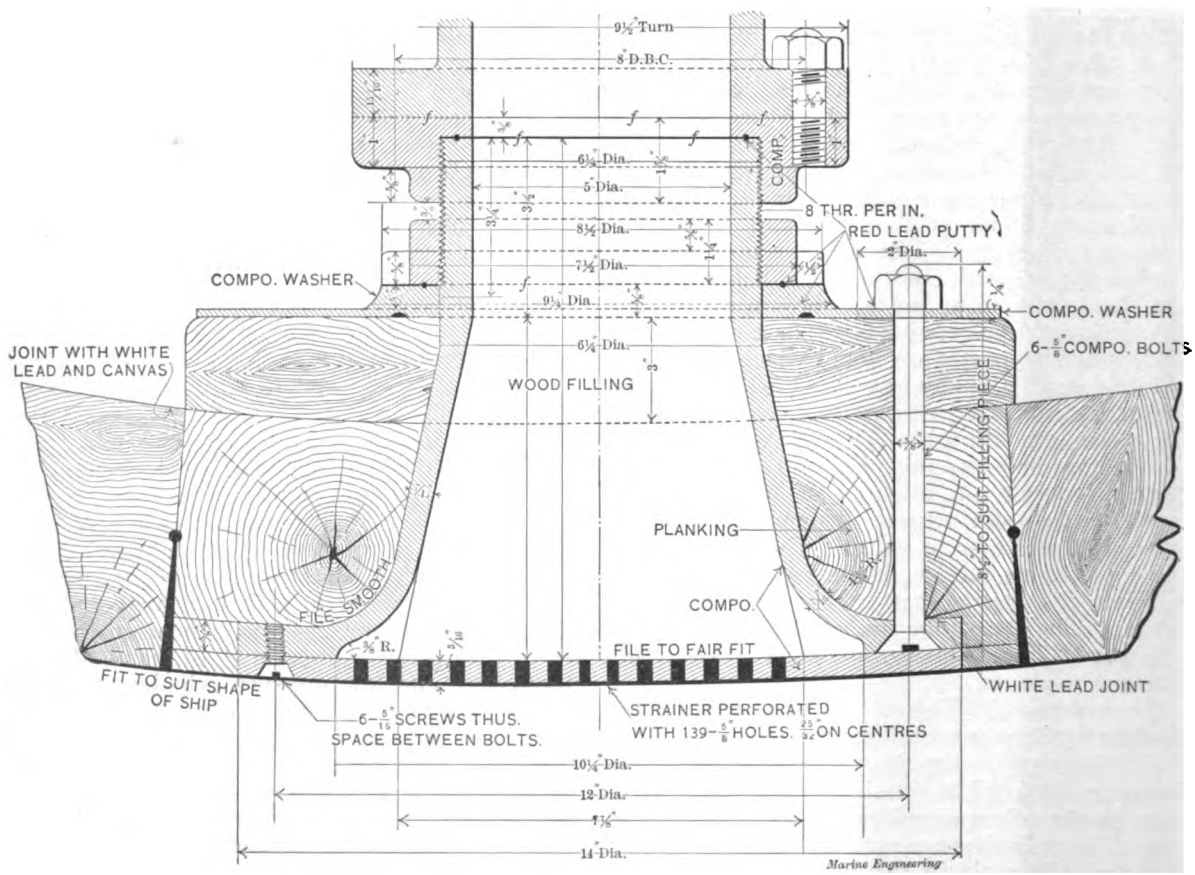
Laird Bros. & Co., Birkenhead, on the Mersey. Plant old, but output very large. They have large docks capable of building battle-ships over 400 ft. in length, and have one at the present time nearly that length, which will weigh about 15,000 tons, and will be floated out of the dock complete, with armor, engines, boilers, etc. The engines for this ship are triple expansion twin screw, and are of a good strong design, with a liberal display of bearing surface, the valve gear being especially heavy. The faces of the eccentrics are very broad. The cylinders for the torpedo boat engines are fitted with piston valves on all of them. The intermediate and low pressure cylinder valves are of enormous size compared with the bore of the cylinders. The valve seats are without bushings, the ports being cut through the casting after the seat is bored out. The bodies of the piston valves are of brass, machined whenever possible to do so, and made as light as consistent with good work. The valves are fitted with rings and great care seems to be taken with the valve gear in

Digitized by Google

fitting up. Some of these large valves have the "Joy" assistant steam cylinder, which takes the strain off the valve gear to a great extent. The columns of these engines are very light, but well braced. The cross girders of the bed plates are of steel castings and very strong. They are not fitted to the floor plates, but are bolted between fore and aft steel channel bars, which take a bearing on the longitudinal in the vessels. The lower bushes for the main journals are round bottomed, and lined with white metal. The keels on all of these fast boats are cut away from nearly amidships, and the bottom extends with a long, easy curve up to the water line at the stern.

Fitting of Sea Valves to Composite Vessels.

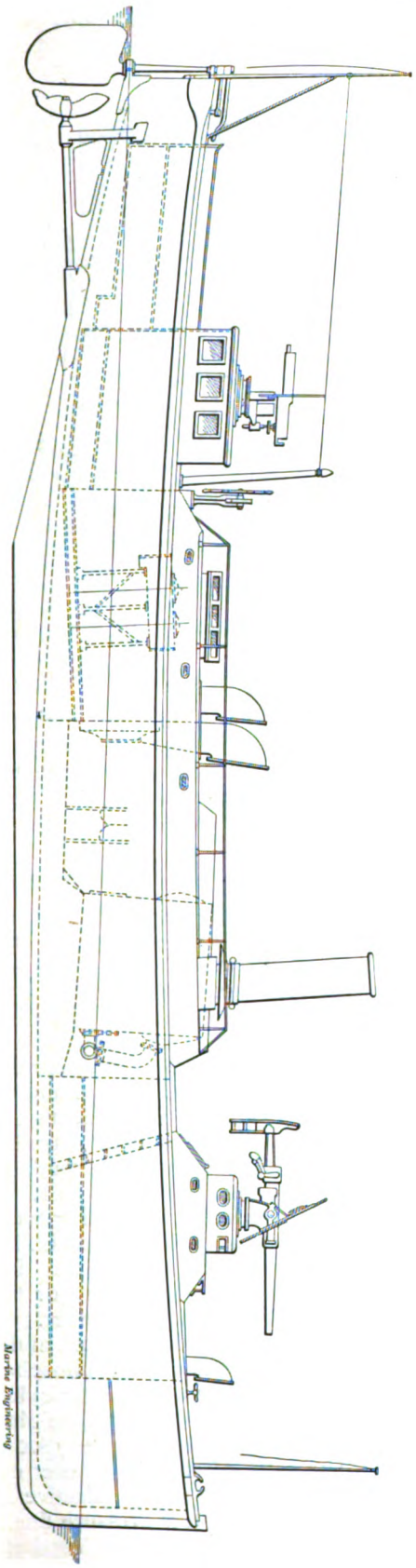
The fitting of the openings for sea and injection valves is a very important matter on both steel and composite built vessels, especially so in the latter class. The method universally adopted on steel vessels, of riveting wrought iron stiffening rings around the opening, provides a safe and rigid seating for the attachment of the valve boxes. In composite vessels the conditions are such, with planking only four or five inches thick, and the frames spaced two feet or more apart, that great care must be exercised, not not only to provide a solid seating, but also to prevent leakage through the seams. The accompanying sketch shows the method adapted by Engineer-in-Chief John W. Collins in securing the sea and injection valves to the new composite Revenue Cutters Manning and McCulloch. This, it will be seen, consists of a composition cone, put in from the outside, with a thread cut on the inboard end, and a flange fitted outboard. To provide the extra stiffness, a circular piece of wood is fitted on the inside of the planking, and a joint of white lead and canvas made between it and the skin of the ship. A thin composition washer or stiffening plate, as shown, is put over the nozzle, and set up snug by a composition nut screwed down. In the bottom of the washer is a groove, which is filled with red lead putty, thus making a water-tight joint, under the washer. A flange, corresponding to the flange on the sea or injection valve, is screwed on the top of the cone, to which the valve is bolted. Composition bolts pass through the outward flange on the cone, and the washer on the inside, as shown, thus providing a permanent and rigid fitting. The perforated strainer on the outside is of composition, and made flush with the outside of the planking. The combined area of the 5-8 in. holes in the strainer is equal to twice the area through the valve, as is customary, in order to provide ample opening in case some of the holes become plugged up by seaweed or other obstructions.



SKETCH SHOWING METHOD OF FITTING SEA VALVES TO COMPOSITE VESSELS.

Digitized by Google

TYPE OF STEAM PINNACE ADOPTED BY THE ADMIRALTY FOR THE BRITISH NAVY.



SECTIONAL VIEW STEAM PINNACE, FOR EQUIPMENT OF LARGE WAR VESSELS.

A very efficient and handsome type of boat now being built for the British Admiralty is here illustrated and described. The Thames Iron Works has on hand a contract for a large number of such vessels. The section here shown is of one of the largest boats with a length of 56 ft.; breadth, 9 ft. 9 in.; depth, 4 ft. 7 in., and displacement at load draught of 17 tons. The boats will form part of the equipment of large battleships and cruisers for such purposes as surveying and sounding along shore, or for the exploration of rivers, or in other places where a light draught, manageable and roomy boat is needed.

The hulls of these boats are constructed of two thicknesses of teak planking, the inner one being laid diagonally, and the outer longitudinally, secured to frames, of Canada elm, steamed and bent to shape; the beams being of galvanized steel, as are also the five bulkheads—four of which are water-tight—with which each boat is fitted. They are built on the "turnabout" system, having straight stem and cutaway stern, as shown in the engraving. Internally the boat is fitted, forward of the boiler, with a forecastle for the crew, and aft of the engine space, with a comfortable cabin and cockpit for the officers.

The armament consists of a 3-pounder quick firer, a 45-in. Maxim, and two 2 sets side dropping 14-in. Whitehead torpedoes.

The propelling engines are of the compound inverted-cylinder type, the cylinders being supported on turned steel columns well stayed together, and carrying the piston-rod guide-bars, the engines being inclined to suit the propeller shaft. They drive a three-bladed gun-metal screw propeller, 3 ft. 4 in. dia., which is supported by an A bracket and sleeve piece of gun-metal, as shown, and are capable of developing about 220 I. H. P. The engine is fitted with a surface condenser, built of copper plate with gun-metal doors, and its tubes are so arranged that the cooling water passes once through them; this water being supplied by a centrifugal pump having a 10 1-2 in. dia. impeller, driven by an independent engine, with a cylinder 2 1-2 in. dia., and 2 in. piston stroke. The air pump is driven by a small crank from the main engine shaft, and is, like the engines, designed for a very high speed. To this end the whole of the machinery fitted in these boats is of the lightest possible description, every device having been adopted to keep down the weight.

Steam for the engines is supplied by a Thames Iron-works water-tube boiler, working in a closed stokehold, with an air pressure of 2 1-2 in.

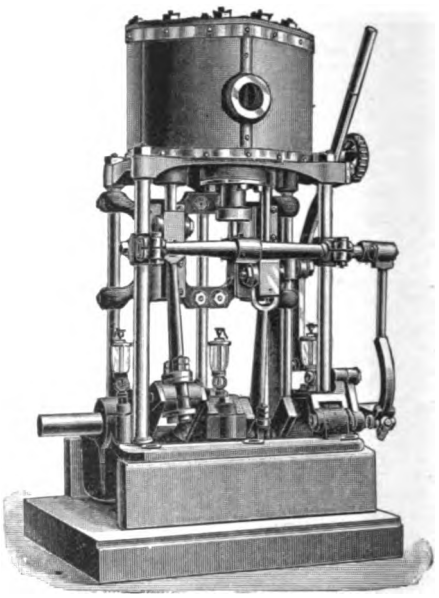
On the official trial of the first of these boats, displacing over 17 tons, a mean speed was obtained of 14.6 knots, with 214 I. H. P. developed by the engines. We are indebted to The Engineer, London, for the illustration from which the sectional view was prepared, and also for the details of construction.

Digitized by Google

IMPROVED APPARATUS.

Small High Speed Forbes' Engine.

In designing and building small engines there has been a general tendency to do a certain amount of real designing and considerable guess work. Small parts must be considerably larger than calculations would show proper, simply because if made just right the difficulty of machining is too great, so many parts are let go almost any size or shape. This has answered fairly well in slow speed engines, but when speeds of 500 revolutions and over are to be provided for the guess work system has to be dropped. It is not to be supposed small engines can conform to recognized formulæ throughout, for obvious reasons, but closer regard to them can be given. In the engine herewith illustrated the builders, W. D. Forbes & Co., have striven to go as far toward proper designs as practicable, and great care is shown in all the details. It will be noticed that the crosshead guides are somewhat of a departure and act as a brace for the columns. The crosshead shoes of brass are on the guides, as in so placing them the crossheads can be made lighter, they being thus relieved from any bolts for holding or adjustment; the latter, difficult to make nicely, and the former, open to the danger of shaking loose; but the main gain is the lightening of the reciprocating parts. The valve is of the piston type and distributes steam to both cylinders. The crossheads are forged on the piston rods and are fitted with brasses for the crosshead pin, the take up being by means of a wedge on the lower side of the brasses to better compensate for wear on the crank pin brasses, which results in shortening the connecting rods. This is a matter of considerable importance, as the clearances in the cylinders are kept down to the least possible limit. The connecting rods are hollow and are fitted with a tool steel pin, and the crank and brasses are made as light as possible. This style of connecting rod gives considerable more strength and stiffness than can be obtained by having the crosshead pin brasses on the forked end, and the pin solid in the crosshead. The Marshall valve gear is used on the engine illustrated, and is very satisfactory, but usually the makers fit their engines with the Stephenson link of the double bar type. The crank and all forgings are, of course, of steel and without welds, and the pistons are turned all over and are also of steel. The engine illustrated is 3 in. dia. and 4 in. stroke, double cylinder with cranks set at 180 deg. The greatest care is taken by the builders to insure a fine running balance, and the engine has been run at 800 revolutions most satisfactorily. Its usual speed is, however, 500 revolutions. Oiling devices are fitted to all surfaces so as to allow a constant supply at all times. This style of engine is also made compounded and for direct connection with dynamos, when either a throttle or automatic governor is supplied, the latter being especially designed, and taking up very little space, its body being forged on the crank. This makes a most satisfactory



HIGH SPEED FORBES' ENGINE.

job. W. D. Forbes & Co. are aiming at a very high grade of engines, and those interested can obtain every information by writing to them at 1300 Hudson street, Hoboken, N. J., or they will be very welcome at the shop.

Steam Pump for Use on Yachts.

A new steam pump designed especially for use on yachts is shown in the accompanying illustration. The requirements on yachts and launches are so different from those of larger work that this pump has been specially designed, having in mind a combination of minimum of weight with a maximum of strength, compactness and effective working capacity. This pump is designed to feed boilers carrying steam at high pressures, and it can be placed almost anywhere. The covers are fastened with 1-2 in. studs with 1 3-4 spaces between the centers so as to secure unyielding joints to hold the packing securely. The pump is 23 in. long, just under 12 in. high, and 9 in. wide without deflecting valve. It is 11 in. wide with deflecting attachment for turning the exhaust into the suction chamber. The steam cylinder and yoke are tough iron, and the water cylinder plate and hood are phosphor bronze. The steam cylinder is 6 in., water cylinder 2 1-2 in., and the stroke 4 in., total weight 125 lbs., and designed maximum capacity 1,800 gallons an hour. The ratio of steam to water cylinders is 5.77 to 1, in order to obtain effective speed with working steam from low pressure line. A number of these pumps have been installed on some

Digitized by Google

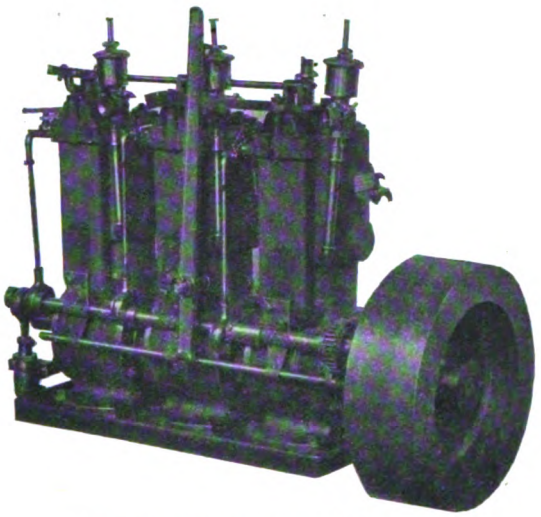
of the neatest yachts of the season. They are manufactured by the Battle Creek Steam Pump Co., Battle Creek, Mich.

Self Starting Gasoline Marine Engine.

The accompanying illustration shows a 10 H. P. three cylinder, reversing and self starting gasoline marine engine, manufactured by the Wolverine Motor Works, Grand Rapids. This engine is of the latest and most improved pattern, and contains, the manufacturers claim, many points of superiority over older types of gasoline engines. It is of the two cycle type, and receives three impulses at each revolution of the crank shaft. It turns very steadily, and can be run at a high rate of speed without any perceptible vibration. The space occupied, and the weight, are small for the power developed. A 10 H. P. engine, complete with fly wheel, can be placed in a space 36 in. in length, 16 in. in width, and 28 in. in height. These engines can be reversed as easily as a steam engine, the going ahead or going astern motion being controlled by a reversing lever, which is simply moved to and fro. The engines are built, at present, in various sizes, from 10 to 30 H. P. for the three cylinder type, and from 3-4 to 20 H. P. in the single and double cylinder types. The material used is subjected to tests, and the workmanship is excellent. The manufacturers have recently furnished a 38 ft. launch equipped with one of these motors to the U. S. Government for the use of the engineer in charge of the dredging work on Grand River, at Grand Rapids. The headquarters address of the manufacturers is 12 Huron street, Grand Rapids, Mich.

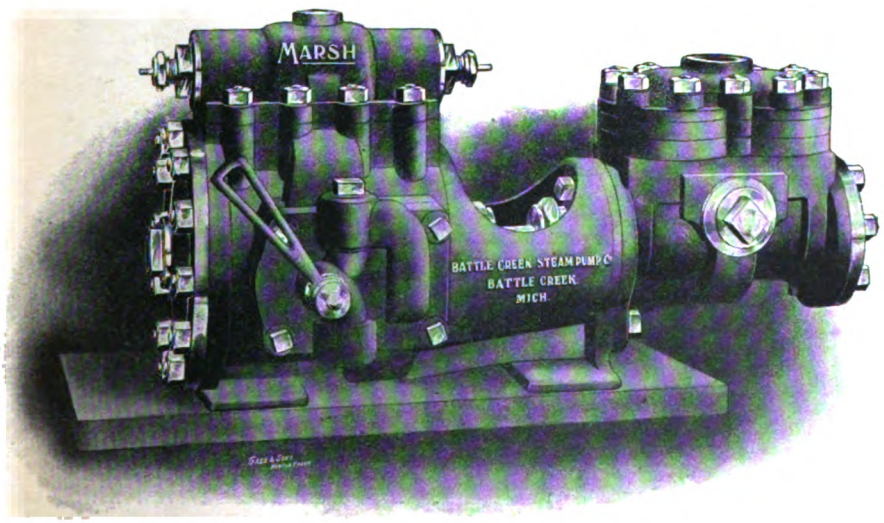
Direct Connected Lighting Plants.

There are limitations imposed upon the builder of generating apparatus for use aboard ship much more exacting than those which usually confront the designer of the similar apparatus for use ashore. The plant on ship must occupy the least possible space for a maximum output, it must be highly efficient, and give its full load at constant voltage, with little attention,



WOLVERINE GASOLINE MARINE ENGINE.

under varying conditions of steam pressure. With supply from the main boilers at high pressure and exhausting into the condenser, or on much less pressure from the donkey boiler while running simple. The dynamo must be built to run cool in a hot engine room practically without ventilation, and also be proof against injury, even when freely besprinkled with sea water. These, of course, are extreme conditions, but they exist, nevertheless, for in older boats the plant has generally to be put wherever it fits. These conditions have been kept in mind by the Rushmore Dynamo Works of Jersey City, in designing their direct connected generating sets. The illustration shows one of the new sets of the 20 K. W. capacity at 350 revolutions per minute with 25 H. P. engine. The dynamo has but one bearing, which is self-oiling, and has a new form of settling chamber which removes all sediment from the oil. The frame is extended and carries the engine. The armature is of the iron clad type wound with continuous copper bar on a new wave system. It is insulated with mica, and guaranteed against injury



MARSH YACHT STEAM PUMP.

Digitized by Google

when saturated with sea water. The engine is of the marine type, with frame of finished steel bar, which gives great strength with least possible weight. The crank shaft with counter weights and couplings is one

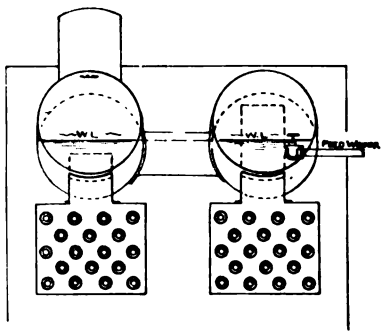


FIG. 2. END VIEW DURR BOILER.

solid steel forging machined all over and drilled hollow, and bearings are of large size to carry the weight of the armature. There is no coupling, but the engine flange bolts directly to the armature core body, thus saving space and weight, and insuring perfect alignment. The automatic cut-off governor is very powerful and regulates within one per cent. The Rushmore Works build also a complete line of high power projectors, ranging in size from 10 in. to 72 in., and taking from 5 to 300 amperes. They are now building a number of 30 in. naval projectors for the large battleships, with electrical distant control mechanism. A machine weighing three tons which will grind the parabolic lenses up to 6 feet dia. with an

RUSHMORE MARINE PROJECTOR.

accuracy heretofore considered impossible is now in use. The cut shows one of the latest type projectors with parabolic lens as used on the trans-Atlantic liners.

Durr Water-Tube Boiler.

The distinctive features claimed for this boiler are the means by which the tubes are fastened in the water chamber and kept tight without the usual rolling or expanding in the tube sheet, and

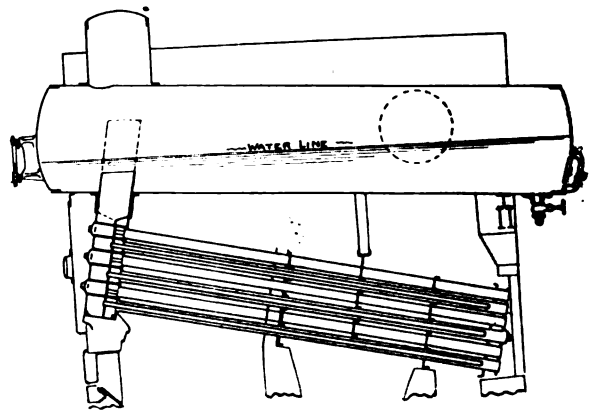
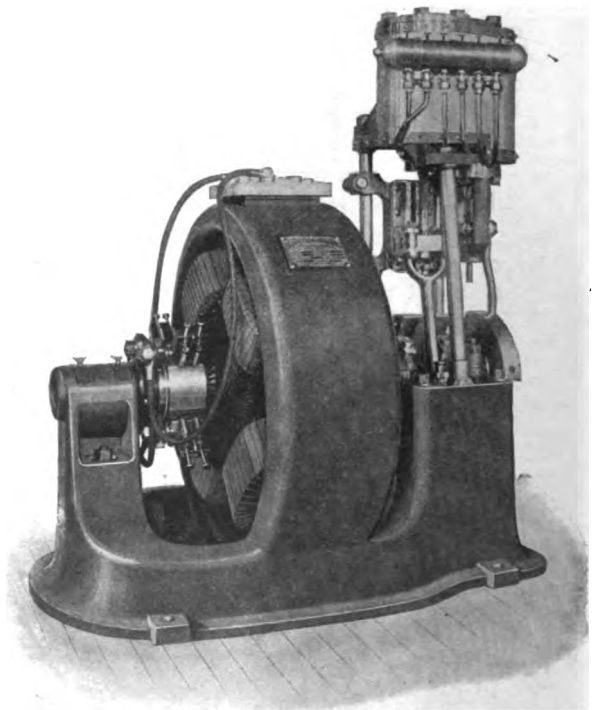


FIG. 1. SIDE ELEVATION DURR BOILER.

without packing of any kind; the method of circulation by which the feed water and the steam carrying water are kept separate; and the circulation of the steam by which all moisture is separated so that steam enters the throttle valve per-



DIRECT CONNECTED LIGHTING SET.

fectly dry. Fig. 1 shows an elevation of a boiler ready for work. Fig. 2 is an end view of the same, and Fig. 3 is an enlarged view of tube and portion of water chamber. It will be noticed that

Digitized by Google

the tubes are fastened only at one end, the other (rear) end being closed by a cap and supported on a rack. The method of fastening without expanding in the tube sheet will be readily understood from Fig. 3. The tubes have a collar welded on; this is turned in a lathe perfectly round and true, and is tapering; the tube is inserted through the front into the tube sheet, which is bored conical, and the tube is pressed against this conical seat by the steam pressure. The front is closed in a similar manner by a conical plug also held tight by internal pressure. It is a matter, therefore, of but a moment to remove or insert a tube. Indeed, in marine boilers subject to long periods of idleness, the tubes can all be removed in a short time, and cleaned on laying up, if desirable. By far the most important point, however, is that the tubes, being fastened only at one end, are left free to expand lengthwise, preventing entirely the bending of the tubes and consequent liability to leakage at the tube sheet, so often seen in other boilers. Referring to Fig. 1, the feed water enters at the upper right hand drum. It will be seen that the connection to the water chamber here is extended up and considerably above the usual water level. The feed water is therefore made to travel back, and at the rear end of the drum flows across and forward into the left hand drum; and here it finally enters the water chamber. This latter is divided by a separating wall, shown in Fig. 3; the front part of the chamber stands in connection with the left hand drum; the feed water, therefore, enters this side and flows into the feed pipes, shown in the center of each tube. It is carried back, and, returning through the tube, is heated, and the steam and water is carried up through the rear part of the water chamber and into the right hand drum. Now the separation of the water takes place as the steam travels back and through into the left hand drum. Here it is eliminated because of the inclination of the drum; the velocity of the steam is constantly decreased on account of the constantly increasing steam space, and that this is correct has been proved, the manufacturers say, by independent tests. Fig. 4 shows a view of a marine boiler of 2,000 sq. ft. water heating surface and 50 sq. ft. grate surface. The manufacturers will grant license for the manufacture of these boilers in the United States. They are represented in this country by Viggo V. Torbenson, Westville, N. J.

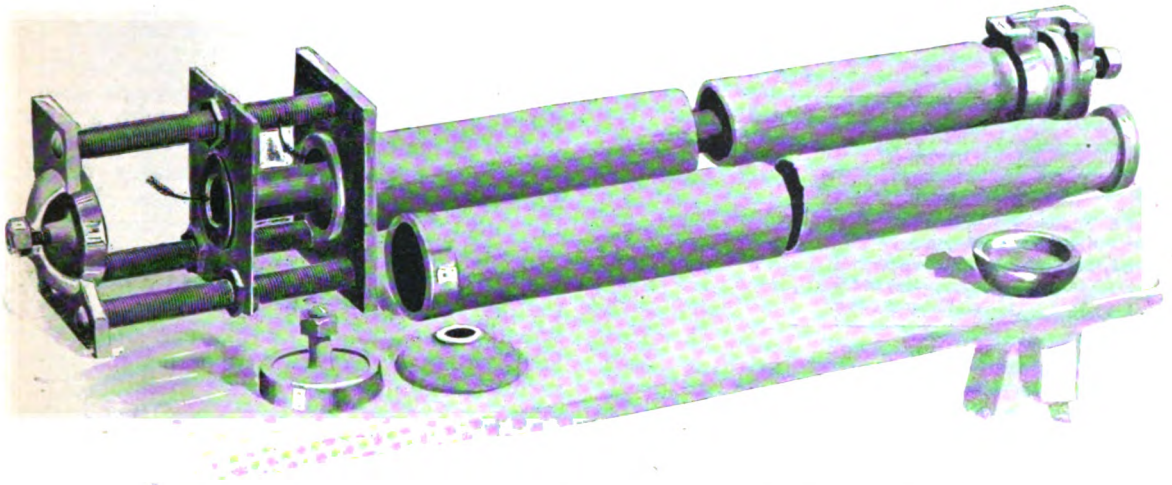


FIG. 3. DETAILS OF TUBE CONNECTIONS. DURR WATER-TUBE BOILER.

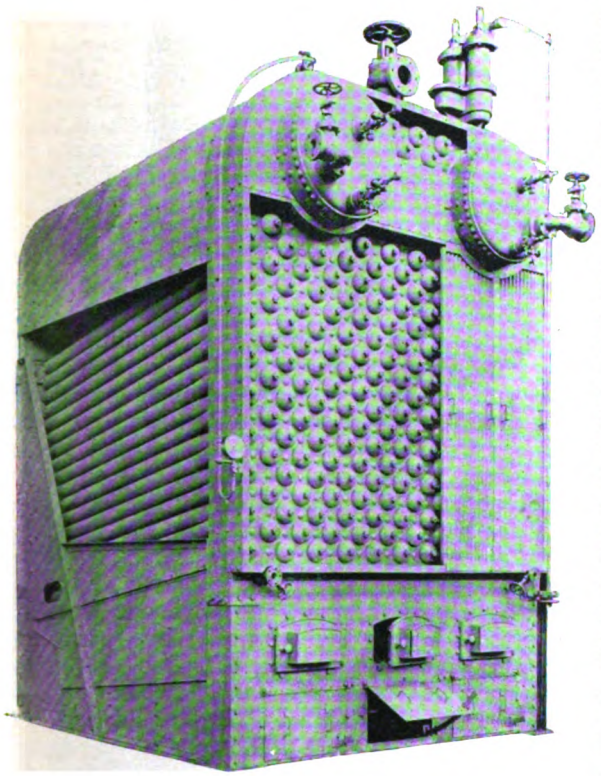


FIG. 4. DURR BOILER FOR STEAMER.

Digitized by Google

MARINE ENGINEERING

PUBLISHED MONTHLY

BY THE

MARINE PUBLISHING COMPANY,

World Building - - - New York.

H. M. SWETLAND, President and General Manager.
H. L. ALDRICH, Vice-President and Business Manager.
A. B. SWETLAND, Treasurer.
H. F. DONALDSON, Secretary and Editor.

S. W. ANNESS, Southern Representative,
Philadelphia, Pa., Bourse Building.
L. L. CLINE & Co., Western Representatives.
Detroit, Mich., 47 Hodges Building;
Chicago, Ill., 305 Fisher Building.

SUBSCRIPTION:
Domestic, $2.00. Foreign, $2.50. Single Copies, 20 cents.

Entered at New York Post Office as second-class matter.

Communications on matters of interest to marine engineers, for insertion in the correspondence department, are solicited. These, wherever possible, should be supplemented by rough sketches or drawings, which will be reproduced if necessary to illustrate the subject, without cost to the writer.

Full names and addresses should be given, but publication of these will be withheld where requested.

Under an appropriation of $800,000 made by Congress for the construction of three torpedo boat destroyers, the Secretary of the Navy called for bids, which were opened a few days ago. The circular, which was issued by the Department, informed intending bidders that two of the boats were to be of not less than 230 tons displacement, and one not less than 260 tons. All were to be capable of maintaining an average speed of not less than 30 knots for two hours, and in all their parts the boats were to be of domestic manufacture. Ten bidders submitted estimates, and complied with all the legal requirements, so that they will probably be eligible competitors for the award to the lowest best responsible bidder. It will be noticed that the lowest may not necessarily be the best. The bidders include some of the most responsible concerns in the country, and some which never before figured as competitors for this class of work. An inspection of the bids is interesting. It will be seen that the prices range from $680 to $1,000 a ton, with the average about $750 a ton. This is certainly a low figure, and especially so when compared with the prices which obtain abroad. The British builders who have been generally credited with the advantage of being able to turn out work more cheaply than the American yards, get an average of $1,000 a ton for this class of work. This is a competitive figure, and one made by builders who have often as many as a dozen boats of this type, in various stages of construction, in their yards at one time. The great difference is all the more remarkable when the exceptionally exacting and, so far as some of the bidders are concerned, unfamiliar nature of the work proposed to be undertaken is borne in mind. If the figures submitted represent the cost of this work, and a fair profit to the builder, they give the lie to the oft repeated statement that ship construction is dearer here than elsewhere. On the contrary, if the prices do not stand for this, bidders manifestly must have put in low figures for good and sufficient reasons. The intention to gain experience in this class of work with a view to further home or foreign orders, or the desire to keep yards busy during a slack season, might be actuating and commendable causes. It will be the duty of the Secretary of the Navy, however, when the awards are made, to have strict attention given to the construction of these vessels, so that every detail shall be carried out in the most scientific and workmanlike manner. A good start has been made by the issue of general requirements which prescribe certain limitations of design, material, and construction. The scandalous favoritism and empiricism which, for instance, made possible the use of odd sizes and bastard threads is properly stopped. It would be well if those concerned in the building of these boats would keep in mind the uses other than spectacular fine weather runs to which destroyers may be put. It is not toys for students of navigation that are needed, but good staunch seaboats, that can fight and win. Boats that can maintain a high speed with always a spurt in reserve. Boats that will not break down or blow up, and that can be repaired with such tools and materials as are available in any yard. The bids are as follows:

George Lawler, Boston, one boat, 410 tons for $280,000; Bond Equity Trust Company, one boat, 270 tons, for $269,000; John H. Dialogue, Camden, N. J., one boat, 243 tons, for $243,000, or two for $480,000; Bath Iron Works, Bath, Me., one boat, 300 tons, for $217,900, or two for $432,000; Wolff & Zwicker, Portland, Ore., one boat, 249 tons, for $214,500, or two for $424,000; Charles Hilman Ship Building and Engine Company, Philadelphia, one boat, 270 tons, for $230,000; William Cramp Ship and Engine Building Company, Philadelphia, one boat, 340 tons, for $245,000; Gas Engine and Power Company, New York, one boat, 235 tons, for $210,000, or two for $410,000; Union Iron Works, San Francisco, one boat 330 tons, for $245,250, or two for $490,500; one boat, 225 tons, for $225,000, or two for $440,000; Columbia Iron Works, Baltimore, one boat, 230 tons, for $210,000, or two for $415,000; one boat, 230 tons, on different plans, for $195,000, or two for $385,000; one boat, 260 tons, for $225,000, or two for $444,000; Harlan & Hollingsworth, Wilmington, Del., one boat, 280 tons, for $244,000, and one boat, 340 tons, for $235,000, or both for $449,000; one boat, 267 tons, for $212,000, and one boat, 340 tons, for $235,000, or both for $447,000; two boats of 340 tons for $467,000; two boats of 276 tons for $425,000, and two boats of 267 tons for $421,000.

Digitized by Google

DIFFICULTIES MET WITH IN HIGH SPEED ENGINE CONSTRUCTION.

A serious mishap, which occurred recently on the British torpedo boat destroyer Star, is the subject of interesting comment in Engineering, London. The mishap was subsequently attributed to the giving way of one of the crankpin bearing bolts, which was flawed. The comment of our contemporary is the more interesting as it applies to this class of boats in general.

The serious accident which occurred to the torpedo boat destroyer Star illustrates very forcibly the unforeseen difficulties that arise with every advance in marine engineering practice. The vessel was on her trial in the Solent, and had been steaming at her full speed for about a quarter of an hour, when the starboard low pressure cylinder split. The steam was quickly shut off by the stop valve, but this operation naturally took some time. Five of the contractors' men were scalded about the face and hands, and were sent to the hospital. The Star is one of the fifteen 30 knot boats ordered by the Admiralty last year, and for eight of which Palmer's Shipbuilding Company undertook the contract. No one will suppose that the experienced designer of the Star's machinery—even if there were no Admiralty overseers—did not allow sufficient section of metal in the low pressure cylinder to withstand any pressure that could arise in the normal course of events. This vessel had already gone through some rather stiff trials with very creditable results. On her first run after being launched she made over 30 knots on the measured mile. On her second trial she was loaded with over 40 tons, and made just over 31 knots as a mean of three hours' steaming, the air pressure averaging 3 1-4 in., and the steam pressure being 232 lbs. The engines have cylinders 18 in., 27 1-2 in., and 42 in. dia. the low pressure stage not being divided into two cylinders. The slide valves are all of the piston type. The stroke is 18 in. There are four Reed water tube boilers.

The accident is attributed in the report to a "split" cylinder, and probably this is the correct expression to use. The designer of light, quick-turning engines, such as those fitted in destroyers, which run up to 400 revolutions a minute, has to reduce the clearance to the lowest permissible limits, in order to obtain the needful efficiency. There is in such cases very little space left at the end of the stroke for water that may be present in the cylinder. Such water has, therefore, to be compressed into a comparatively thin film with much surface. Although there may be the usual methods of relief, either through special relief valves or the slide valve being forced off the slide surface when flat valves are used, the action is so quick that any water at a distance from an opening has not time to get around. The consequence is that there is a heavy blow, most likely on one side of the piston only; this tends to tilt the piston and bend or crack the rod. If this action be continued, it is quite possible that the piston may get skewed, and thus bring to bear stresses which the walls of the cylinder are not calculated to withstand. The tendency of opinion seems to be to look on relief valves for quick-running engines as useless appendages, for the reasons stated; but though they are not a perfect safeguard, at least they reduce the risk of mishap. They will allow some water to escape, and thus prevent an accumulation which might otherwise prove fatal.

It is very certain that some means will have to be taken to overcome this danger. One can never be sure that a quick-steaming boiler, of whatever type, will not start priming at any minute when running at full power. Salt water getting in will almost invariably produce such an effect, and it is really exceedingly alarming to hear the hammer of water in the cylinders even at low speeds. Exactly how the difficulty will be overcome it is not easy to forecast. The most efficient remedy would be—as ordinary relief valves do not extend over a sufficient area—to make the cylinder-cover all relief valve, with perhaps long holding-down bolts and spiral springs round them. Even if the obstacles in the way of such an arrangement—the difficulty of making a steam-tight joint, for instance—could be got over, it would only deal with the top cover, as at present arranged. A more obvious and practical method of dealing with priming water is by the use of separators. These must be of ample size in order to be efficient, and, as they must be made to stand the full boiler pressure, they necessarily add considerably to the weight of machinery carried. We think that the vortex action might be more often utilized in reducing the size of steam separators. By aid of the centrifugal forces acting in a small-diameter cylindrical separator, placed vertically, the heavier priming water could be brought to rest and be drawn off at the bottom, whilst the steam would be more quickly affected by the draught to the engine. Naturally the inlet orifice into the separator would have to be tangential to the circumference. The best designed separator, however, cannot be relied upon beyond a certain point, and it is an open question whether it would not be more profitable to throw the extra weight into a larger steam drum—in the case of water-tube boilers—and thus avoid additional complication. The relief obtained by the ordinary slide valve receding from the cylinder face when pressure inside exceeds the total pressure on the back of the valve, is not generally present with piston valves, but a device has been introduced whereby the valve is allowed to recede through being placed in an outer case.

No doubt the ingenuity of the talented designers who produce the machinery of torpedo craft will be equal to getting over this undoubtedly serious danger, as it has surmounted others that have arisen in times past; and, indeed, the whole history of engineering progress has been one of creating and overcoming difficulties in order to purchase increased efficiency. No sooner is one engineering problem solved than it gives rise to others more complex, and doubtless the Sisyphian round will continue so long as a force of nature remains to be bent to the use of man. When high steam pressures were viewed from afar it seemed as if the only difficulty that had to be surmounted was to get the requisite strength in boiler shells and furnaces; but no sooner did improved material and design roll this obstacle to the top of the hill than it rebounds in the shape of burst steam pipes and other disastrous manifestations. Now that we have steam of very high pressure plentifully at command, and steam pipes made secure by substituting steel for copper—with or without riveted butt straps, but preferably without—a bridge is made for dangers to travel from the apparatus which generates steam—formerly the great center of anxiety—to that which uses it.

The running of trials of torpedo craft is one of the most risky operations carried out in peace time, as weights are cut down to the lowest limits, and the machinery is then tested in a manner that it seldom is afterwards. It is to be hoped after this sad object-lesson that no more full-speed trials of destroyers will be run without a medical man being present.

There is one simple fact well worth bearing in mind in case of an escape of steam into an engine room or stokehold: Unless you can escape immediately, lie down, especially if the burst pipe or cylinder be overhead. Air is heavier than steam, and, moreover, a bad conductor of heat. There is sometimes a stratum of comparatively cool, fresh air on the floor plates, whilst the upper part of the engine room is at boiling point. Of course, if the escaping steam were directed downwards this hint would not apply.

Digitized by Google

CORRESPONDENCE.

[*We do not assume responsibility for the opinions expressed by correspondents.*]

Another Experience with Cylinder Lubrication.

I have been interested in the correspondence in your April and May issues in regard to oil deposits in cylinders. Apropos of that correspondence, I have little to say in regard to cylinder deposits, except that in five years as an engineer at sea I never found any trouble from them, for the very simple reason that we never supplied oil to the cylinders. I do not say that the cylinders never got any oil. They were thoroughly oiled before the beginning of a voyage, when they were open for overhauling, and when running they probably got a little, which may have passed through the stuffing boxes from the swabbing of the piston rods, but they certainly got it in no other way. There were lubricators attached to the engines, but they had not been used for so long that I don't think we could have used them if we had tried. This was on voyages from London to Australia and London to Indian ports, lasting from four to six weeks, with a stop at Port Said and sometimes at Colombo of a few hours. The engines were triple and quadruple expansion engines, using steam at 165 lbs. and 180 lbs. pressure. The cylinders were opened and pistons adjusted and oiled at each end of the trips, the best mineral oil being used, and I may say we prided ourselves on the appearance of our cylinders. Your correspondent, "Ralph," in April issue, may also find here an answer to his question.

KANGAROO.

Packing Steam Boiler Water-Gauge Glasses.

Since the introduction of high-pressed steam boilers the breakage of gauge glasses has caused great annoyance, and given rise to numerous complaints, and many suggestions have been made of introducing substitutes; but the question arises whether the substitutes would be any better, and whether the gauge glasses now in use—if of good quality—are not sufficient for all that is required of them. I am of opinion that they are, provided always that the quality is good. I have made a large number of experiments with the Perth gauge glasses, and find that they will stand a hydraulic pressure of 5,000 lb. to the square inch without breaking. You may take one of the glasses in your hand by one end and insert the other into a flame that will bring a red heat on it in about half a minute, also without breaking. Such being the case, the question naturally arises, Why should a glass that will stand the variation above described, and that can be subjected to 5,000 lb. hydraulic pressure, be broken with 200 lb. or 300 lb. steam pressure? To that it might be replied, that in one case the tests are done separately, while in the other the heat and pressure are combined. This looks like a formidable objection; but it is only so in appearance, as I am quite sure I will be able to prove that the glasses are broken neither by the pressure nor the heat, but by the expansion of the glass being interfered with. Increased pressure of steam means increased heat, and the heat and pressure combined means an increase in the expansion of the glass; and if the glass is packed too tight, or in any way to interfere with its natural expansion, breakage is unavoidable. It must break the moment it reaches the point of resistance. In regard to the packing of gauge glasses, there are a number of points to be noticed. First, you must have a good gauge glass. There are glasses in the market that will not stand 200 lb. pressure, pack them how you may, and the glasses must not be too full for the size of the gland; more glasses are broken from this cause than would be credited, if the amount were known; in the second place, the gauge cocks must be set perfectly true, otherwise the glass will have too little space for expansion on the one side, and the packing must be suitable and of the very best quality. Rubber washers of the best quality are not suitable of themselves. With steam at 200 lb. or more, they get softened to pulp in a very short time, and are blown out. To prevent this they should have a ply of asbestos twine or cord on each side of them, which protects them effectively. The next point to be noticed is the screwing up of the glands. You should be able to move the glass with your finger and thumb after the screwing is finished. If you cannot do so, the room for expansion is not sufficient, and breakage will result. With the glass left easy, there will be a little leakage when the steam is put on; but this will take up as soon as the glass and the packing expand. To ensure perfect safety, however, it would be as well to slacken the nut almost to leaking point again. One point to be particularly noticed is that the glass breaks most frequently at the steam end of the gauge cock; that is because the steam is hotter than the water, and causes more expansion. This should be kept in memory when screwing up the glands. If these directions are followed, a good gauge glass should stand perfectly well in the highest pressure boiler that has yet been made. As the proper packing of a gauge glass is so important to engineers and stokers, especially where high-pressed boilers are used, I may take the liberty of formulating these hints into a kind of rule: First, a good gauge glass must be used, which should not be too full for the size of the gland; second, a good rubber washer should be used, protected by a ply of asbestos twine on both sides; and, third, the glass should be movable by the finger and thumb after the glands have been tightened up. The steam end of the glass should be left a shade slacker than the water end; and last, but not least, the whole operation should be carried out with intelligence. This last instruction is quite as important, if not more so, than any of the others. I may state that these experiments have been carried out on a steam boiler with a working pressure of 300 lbs. At first there were a great many breakages, but after experience showed what kind of packing was required, etc, it was almost impossible to break one.

JOHN MONCRIEFF, in The Engineer, London.

Perth.

A Correction About Pumps.

In your illustrated article descriptive of the U. S. Revenue Cutter McCulloch, as published in your last issue, we notice you give description of machinery, including the independent air pump of our make. You were misinformed about the type of this pump, as it is not of the vertical "Duplex" pattern, as you mention, but was built on the Blake vertical "Twin" system. There is quite a difference in the two systems, as you will note by the following extract, taken from the official report of the trial trip of the U. S. Cruiser Minneapolis, which vessel is fitted out with similar air pumps, only several sizes larger. The quotation referred to is as follows:

"The operation of this 'Twin' air pump differs from that of the 'Duplex,' where one pump engine drives the steam valve of its neighbor, as here the engine which drives the main steam valves has no other function to perform, and is adjustable to its work. The arrangement for this may be briefly described as follows: The beam which positively connects the main piston rods of the pumps operates (from a point near its center, and by means of rod and bell crank) the slide valve of the horizontal cylinder which lies between the main steam cylinders. The piston of this horizontal cylinder is really the driving engine of the main cylinder steam valves, a function which it performs by means of a system of internal levers. All the ports are of fair size, and the operation of the pump is not only as positive as any Duplex, but is

Digitized by Google

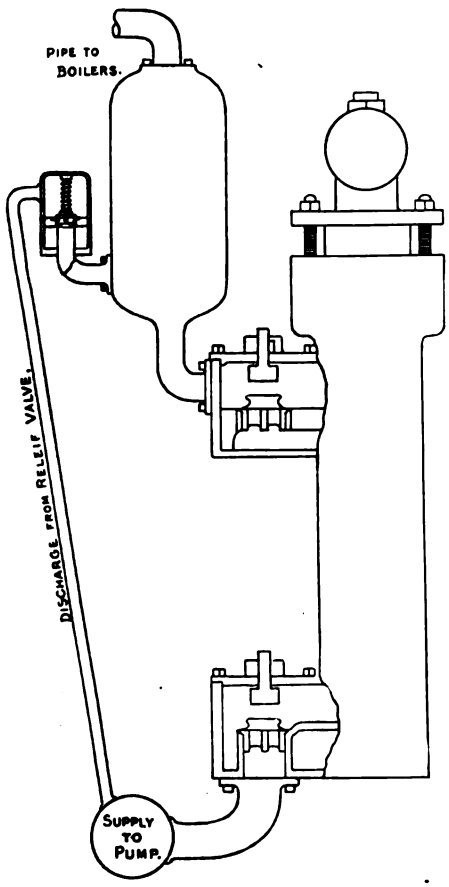
decidedly more regular and complete. The adjustable collars shown on the valve stem of the 'valve driving engine' afford a means for regulating for a full stroke at any speed, while suitable cushion valves give a further control over the action during the stroke, in regulating distribution of work and preventing slamming of foot valves. The power of this 'Twin' air pump is only about one-sixth (1-6) of one per cent of the horse power of the main engines."

Thanking you in advance for publishing this letter,

THE GEO. F. BLAKE MFG. CO.

Texas Discovers the Cause of His Trouble.

As I had trouble with my feed pumps some time ago, and was for a time quite puzzled to know the cause, I gave the problem out to your readers, thinking I might find some engineer who had had trouble similar to mine, and could suggest a remedy, which he or they might be generous enough to impart. I



have since then found the cause of the trouble with my pumps and will in turn inform you that it may be useful to others. Of course, it was like a great many other things, very mysterious until found out, then ever so simple. Attached to the air chamber is a relief valve which is intended to open and relieve the excess of pressure in the feed pipe, should the boiler checks be shut down. The discharge pipe from same leads back to the supply pipe to the pumps. This valve was found to be leaking. It was taken apart at sea and sheet gum washers were put in between the valve spindle and seat, and the trouble disappeared. When we reached port, we "ground in" the valve, and the pumps have worked perfectly ever since. I enclose a rough sketch of the pump to enable your readers to get a better understanding of the problem. I am very much obliged to "C" for his letter of information. TEXAS.

MISHAPS AT SEA.

Collapse of Donkey Boiler Flue.

A case of total collapse is shown in the illustrations of a vertical flue removed from the donkey boiler of the S. S. Ardenberg upon her arrival recently in this port. The flue was of mild steel, 5 ft. 3 in. long and 18 1-2 in. outside dia. and 7-16 thick, lap welded, with a flange at the lower or fire-box end. The water level was 12 in. above the crown sheet, and the bulge in the flue started about 3 in. above this and extended right up about 3 ft., close to the angle iron ring at the top of the boiler. The bulge was about 3 ft. 6 in. long, and 10 in. deep at the point where the steel cracked. The crack was about 5 in. long and 1-4 in. wide in the center. From the appearance of the surrounding metal, the place where the flue cracked was not badly burnt, and the hole, which was drilled just at the fracture, showed that the metal retained its usual properties. The failure did not occur along the weld, as this was perfectly sound after the mishap.

COLLAPSED FLUE OF DONKEY BOILER.

The flue was removed at the Columbia Engineering Works, in Brooklyn, and a new flue of 1-2 in. plate substituted.

Copper Steam Pipe Failure.

The failure of a main steam pipe on the S. S. Indrapura was the subject of an inquiry by the British Board of Trade, in which the necessity for the careful inspection of pipes during the process of flanging was emphasized. The steamer was at sea at the time of the mishap. The main steam pipe of the starboard boiler cracked circumferentially through the solid copper over a length of about 9 in. at the neck of the flange connecting it with a T piece. The steamer has two double ended Scotch boilers. The steam mains are led upwards from the stop valves of the boilers to a brass T piece. From thence a single pipe extends to the stop valve on the engine. The pipes are of copper 1-4 in. thick. The main between the engine and the T piece is about 6 ft. long, and 9

Digitized by Google

in. outside dia. The branch pipes between the T piece and the boiler stop valves are about 14 ft. long and 7 1-2 in. dia. The regular working pressure of the boiler is 150 lbs. More than a year before the accident a crack was noticed at the neck of the flange connecting the main steam pipe to the engine stop valve. The pipe was then shortened, the flange rebrazed, and a distance piece 1 1-4 in. thick fitted. The fracture in the steam main of the starboard boiler is attributed to the vibration of the machinery during very heavy weather, which set up a bending motion at the neck of the flange at right angles to the line of stress. The steam pressure at the time of the break was 145 lbs. per sq. in. The pressure was let down to 120 lbs., and after fourteen hours' steaming, the vessel was anchored in harbor, where the pipe was disconnected and a blank flange fitted next the T piece. The steamer then proceeded under one boiler to Falmouth for permanent repairs. The Board found that the steamer is built with a plate keel, and is not provided with rolling chocks, and, when in ballast trim, labors heavily in bad weather. The steam pipes are arranged in easy bends and angles, which were stated to be not sufficiently elastic to adapt themselves to the conditions which prevail in a light vessel in heavy weather with the engines racing. The Engineer Surveyor-in-Chief made the comment that copper pipes are very frequently injured in the neighborhood of brazed flanges by injudicious heating during the process of brazing on the flanges. In the present instance, however, there was nothing to show that any portion of the fractured pipe had been overheated.

Failure of a Boiler Stop Valve.

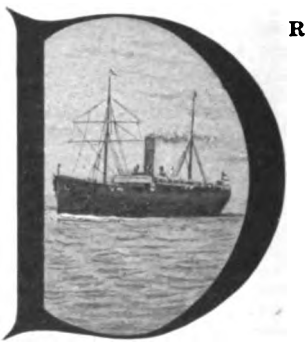
An explosion, the result of a collision of the steam tug Anglia with the wall of the Collingwood Dock at Liverpool, was also considered by the board. This was a very peculiar and unfortunate accident, the chief and second engineers being scalded to death. The boiler was of the usual marine type, 10 ft. dia. and 9 ft. long, with two plain furnaces, each 3 ft. dia. and 6 ft. 6 in. long. The stop valve, which gave way, was on top of the boiler about 3 ft. from the after end. It was jointed to a wrought iron block, which in turn was riveted to the shell. The stop valve chest was of cast iron, the body being spherical in form 7 3-4 in. outside dia., and 1-2 in. thick. The valve was 4 1-8 in. dia., and with its seating was made of brass. The lower neck of the valve was 5 1-2 in. outside dia., and 4 in. inside dia., the metal having a uniform thickness of about 3-4 in. all around the neck. There were no webs connecting the lower flange to the body of the valve. The boiler was not securely fastened in place in the tug, and the stop valve was fitted close against the end of an iron casing which covered the boiler. There was consequently no room for play, should the boiler move in a fore and aft direction. This it did when the vessel came to a sudden stop by contact with the granite wall of the dock. The impetus of the boiler moving forward on its seating brought the stop valve into violent contact with the iron casing and the metal gave 'way at the neck, the valve parting from the bottom flange. For some unexplained reason the orders on the dial of the engine-room telegraph were printed in French, and the pointer was in a go-ahead position when the pilot had rung "full speed astern." The engineers were strangers to the vessel or they probably would not have been in the way when the mishap occurred.

Of the $541,250,000 expended by the British nation on the Royal Navy since the year 1885, a total of $507,151,250 was paid to private contractors, and only $34,099,000 worth of work was done in Government dockyards and arsenals.

EDUCATIONAL.

THE ART OF MAKING MECHANICAL SKETCHES, FOR MARINE ENGINEERS.—1.

BY PROF. C. W. MAC CORD.



RAWING has been happily called "the universal language;" the master of the pencil needs no interpreter, and he speaks more clearly and concisely than the master of the pen. This is true, not only in respect to drawing of the higher class, such as the artist uses in decoration and in pictorial representation, but it applies with equal if not with greater force to the lower order of delineation employed for the guidance of the artisan. And from a merely practical point of view the latter is the more important of the two, as any one will at once see who reflects upon the enormous development and extent of mechanical constructions in this utilitarian age. Because it is in relation to these that the superiority of the graphic language is most pronounced; it is in fact indispensable in their execution. The detail drawings of a proposed structure are what the workman depends upon and must have; and they tell him at a glance, no matter what his native tongue, more than he could learn from a volume of description.

A machinist, then, must possess at least such a knowledge of the principles and methods of mechanical drawing as will enable him to understand and to read with ease the working plans furnished for him to follow; whether he be able to make them or not. And nearly as much may be said of many other artificers as well—the moulder, the blacksmith, the sheet-metal worker, the plumber, carpenter, and cabinet-maker; indeed, of all those engaged in the industrial arts, there is not one to whom such knowledge would come amiss, or who would not feel himself a more competent workman for being thus enabled to execute intelligently any new design that might be brought him.

Now, working drawings are usually made carefully to scale, by professional draughtsmen; and it is right that this should be so, since measurements may be taken directly from the plans, and also because a clearer and better idea of the structure is conveyed when the different parts are shown in their true relative sizes and exact forms. It is not, however, always necessary. A mere sketch, if the dimensions are correctly figured, might be and in fact sometimes is, employed instead. But, although not accurately drawn to scale, and though on occasion made wholly with the free hand, it is obvious that in order to be a safe guide the sketch must convey clearly all the needed information as to size and form. In short, the sketch is neither more nor less than a rough mechanical drawing, and the same principles are involved in the one as in the other.

But, although in a machine shop, rough, full-size sketches made in chalk or charcoal upon smooth pine boards are often used for the guidance of the blacksmiths, pencil sketches are seldom given out to the pattern makers or the finishers; they are most often put in the hands of the draughtsmen, who construct accurate drawings in accordance with them. These, whether inked in or not, are then traced, and from the tracings blue-prints are made for use in the shop.

It is hardly necessary to say to those at all familiar

Digitized by Google

with mechanism, that the design of a new machine is seldom if ever conceived in perfection as a whole. Almost always there are more ways than one to accomplish a desired result, more particularly in regard to the arrangement and proportions of details. And in order to make comparison of these, and thus to decide which is the best, preliminary sketches of approximate accuracy are absolutely necessary, even if the designer be his own draughtsman; and both designer and draughtsman must be able to make them. But the ability to make such sketches is often quite as advantageous to those who take charge of and operate the machine when completed and set at work as to either the designer or the maker. Repairs on account of wear or breakage are always necessary sooner or later, and if the attendant can measure the damaged parts and make on the spot a good and reliable sketch, it is easy to see that the repairs may often be effected in much less time than if he had lacked that accomplishment. Again, the attendant or operative, if of an observing and thoughtful cast, frequently finds it desirable to make some changes in existing arrangements, or to attach some new device to an engine or other piece of machinery. In this case he will find the ability to make clear working sketches, by means of which the proposed change or addition can be explained and carried out if approved, to be a qualification of no small value. In short, this is an accomplishment which should be possessed, not only by every mechanic, but also by every one who has charge of machinery of any kind; particularly marine engineers. It may be acquired, too, in a very practical and useful degree, without the aid of an instructor, by any one who sets resolutely about it. Some of our readers who are thus disposed may lack other facilities for self-instruction. In what follows we shall therefore attempt to give such explanations as will give them a fair groundwork and an understanding of principles; but it must be kept in mind that the best way to learn a thing thoroughly is to do it repeatedly; and proficiency can be gained only by careful practice.

It is possible to make very excellent free-hand sketches, using nothing but a lead-pencil. It requires considerable practice, however, to do it only passably well, even for those gifted with a true eye and a steady hand. And, further, it takes much longer to produce a satisfactory sketch in that way than by the use of instruments; and since for practical purposes the latter method is quite admissible, we unhesitatingly recommend it for beginners.

No expensive outfit, however, is needed. A pair of "school compasses" of the best kind, which may be had for twenty-five cents, will answer for drawing circles in pencil, and subdividing them if required. a common two-foot folding rule of the same valve, will suffice for setting off distances, and on a pinch will serve as a straight-edge. With these and a No. 3 pencil, a sharp knife to trim it with, a piece of India rubber, and a pad of paper of moderate size, our tyro is ready to begin. It is the same old story; in the early times when man lived by the chase alone. "the swiftest men caught the most animals, and the swiftest animals got away from the most men." Clearly, the swiftest men were those who carried the least weight; and so to-day, he who can do without the most things has a distinct advantage in the race. And in this line of work much may be done with little. In the absence of dividers, distances can be very accurately measured and transferred by marking them off upon the sharp edge of a sheet of writing paper, and by folding the paper so as to bring the two marks together, the distance is bisected with reasonable accuracy. A simple folded sheet makes a respectable ruler. By folding it again, bringing the edges of the first fold fairly together, we have a right angle, serving to draw lines perpendicular to each other. Still another fold gives us an angle of 45°. If two points, well separated, be set off at the same distance from a given line and on the same side of it, the line drawn through them will be parallel to the first—all of which is readily done with a paper folded as above. If compasses are not at hand, an arc or even a complete circle can be struck by merely sticking the sharpened point of the pencil through a hole in a strip of paper, using a common pin for a center—a very useful expedient if the radius happens to be too large for the compasses, even if that instrument is at hand. These few instances serve to show that simple expedients will sometimes enable one to do fairly well, even if he does not have the appliances best suited to the work; although, of course, that is no reason why those should not be procured if possible. And, while the few simple articles first mentioned can be made to answer very well, it is not to be denied that he who can spare a little more, can work more conveniently and rapidly if he procures from the instrument dealer a pair of 5-inch compasses, jointed in each leg, with interchangeable points; as well as two ebony-edged triangles—one of 45°, the other of 60° and 30°—to be used as rulers, as well as for drawing lines parallel, perpendicular, and at various angles to each other. If the longest side of each be from 8 to 10 inches long, these will be found very convenient in use.

It is seen that in the above, provision is made only for rough sketching; but, since the principles, and indeed the methods, which we shall explain and illustrate in succeeding articles, are, as already remarked, the same as in making finished drawings, we shall also in due course consider some of the additional apparatus required for their execution.

ELECTRICITY ON BOARD SHIP, PRINCIPLES AND PRACTICE.—1.

BY WM. BAXTER, JR.

A man who understands the operation of a steam engine, but is not versed in electrical science, will say that it is easy enough to understand how a steam engine works, because the steam which moves the piston is something real, and, therefore, an effect is produced by a tangible agent; but in the case of an electrical machine the action is due to an invisible cause. As a matter of fact, the cause is just as invisible in one case as in the other; but familiarity, in so far as the steam engine is concerned, causes this fact to be overlooked, and the heat, which is the real cause of the motion of the piston, is lost sight of, and the steam, through which it acts, is made to take its place. Heat is an invisible force, just as much so as electricity and magnetism. Heat acts through the medium of steam, which is material and tangible, but electricity acts through the medium of copper wire and iron, which are also material, and decidedly more tangible than steam. From these self-evident facts it is easy to see that when the principles upon which electricity and magnetism act are properly understood, the operation of electrical machinery of any kind becomes, to say the least, as simple as that of the steam engine. These principles are not in the least complicated, nor does it require a profound intellect to fathom them, as will be made evident in the following lessons.

Electricity and magnetism are so related to each other, and their actions in many instances are so similar, that formerly it was believed by many that they were one and the same thing. At the present time, however, it is understood that one is the resultant of the other, and, except under certain conditions, the necessary accompaniment of it. The needle of a mariner's compass will point north and south, the reason being that it is itself a magnet, and

Digitized by Google

is attracted by the earth, which is also a magnet. The magnetism of the earth exerts a force that tends to draw any substance affected by magnetism into a north and south position, but its action is more vigorous upon another magnet, owing to the fact

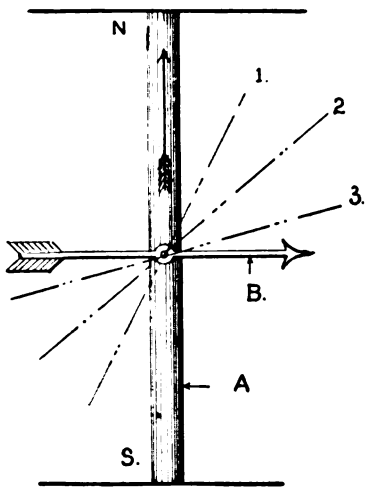


FIG. 1.

that in such a case the force of the earth's magnetism is assisted by that of the magnet; therefore, the pull is the result of the two forces combined. A bar of iron suspended by a string so as to be able to move freely will be drawn into a north and south position, providing its movement into that position is not resisted by a force greater than the earth's magnetism, but it will be prevented from swinging to the north and south line by a resistance much smaller than that necessary to arrest the movement of a magnetized needle of the same size.

Since the magnetism of the earth draws a needle into a north and south position, it is evident that to hold it in any other position will require the application of a force that will oppose the magnetism of the earth. It is also evident that this force must itself be magnetic—that is, if it is not mechanical. To be sure, we could move the needle with the finger and hold it in any position, and the force we would exert would not be magnetic; but to cause it to move without being touched, the force that holds it north and south, which is magnetic, must be counteracted by a similar force—that is, a magnetic force.

If we place a copper wire in a north and south po-

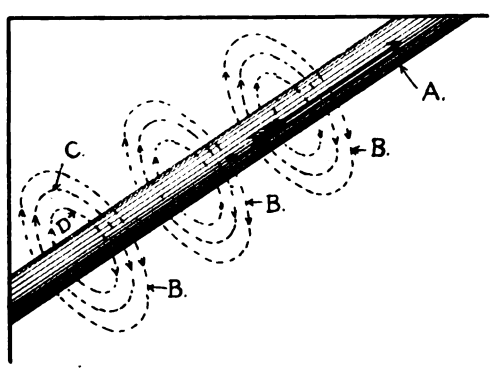


FIG. 2.

sition, as shown in Fig. 1, and suspend over it a magnetized needle, the latter will point in the same direction as the wire, providing there is no electric current flowing, but as soon as a current is passed through the wire the needle will swing around in the direction of the hands of a clock, providing the current runs north, as indicated by the arrow in the figure. This experiment shows us that the passage of an electric current through the wire develops a magnetic force which acts against that of the earth. If the current is very weak, the needle may move as

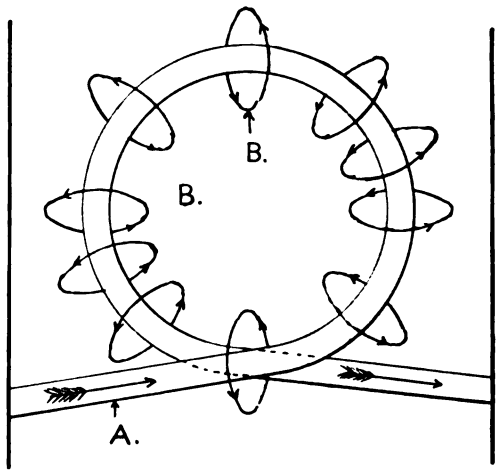


FIG. 3.

far as the line 1 and stop; if the strength of the current is then increased, the needle may move as far as line 2 or 3; and if the current is made sufficiently strong, the needle will reach the position in which it is shown in the figure. From this we learn another fact, and that is, that the intensity of the magnetic force developed around the wire by the passage of the electric current is proportional to the strength of the current.

In this experiment we have assumed the wire to be placed in the north and south position, simply because when in this position the action of the magnetic force developed by the current against that of the earth can be made manifest. If the wire were placed east and west, the needle would be drawn into the position shown in the figure by the earth's magnetism and as the magnetism develops by the current would be in the same direction, its effect would not be seen. It makes no difference, however, in what direction the wire may be, if there is an electric

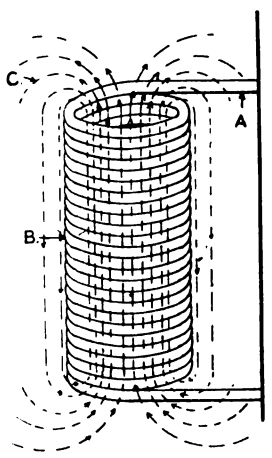


FIG. 4.

current flowing through it, a magnetic force will be developed around it. This is more clearly shown in Fig. 2, in which A represents a wire in which a current is flowing in the direction indicated by the arrow, and the curves B C D indicate the direction in which the magnetism developed exerts a force, or

Digitized by Google

pull, the arrow heads showing the direction in which the north end of a magnet needle would point if suspended along the path of the curves so as to move freely.

Not only is the magnetism developed by the current uninfluenced by the direction of the wire, but it is also uninfluenced by the shape into which the wire may be formed. If the straight wire of Fig. 2 is replaced by a coil, as in Fig. 3, the passage of a current will develop a magnetic force, which will be in the same direction, relative to the current, as in the case of the straight wire, as can be seen from the direction in which the arrow heads point on the curves B of this figure.

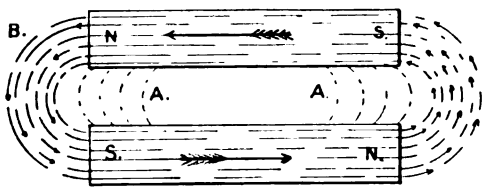


FIG. 5.

If the single coil of Fig. 3 is replaced by one having many turns, as in Fig. 4, the magnetic force will surround all the turns of wire, as indicated by the lines C. In this case the several turns of the coil B will be enveloped by the magnetic force, just the same as the single turn in Fig. 3. If the current passing through the wire in Figs. 3 and 4 is of the same strength, the magnetic force developed in the latter will exceed that in the former to an extent nearly equal to the number of turns in coil B. This is so owing to the fact that the magnetic force developed is in proportion to the strength of the electric current, and the passage of the same current around the coil a number of times is equivalent to increasing the current to the same extent through a single turn. To make this point clearer we will say that if the number of turns in the coil is, say, twenty-five, the magnetism developed will be nearly as great as if twenty-five times as strong a current were sent through a single turn. The statement that the magnetism would be "nearly as great" requires an explanation. The natural inference would be that there would be absolute equality, as in both cases the total current flowing around the circle would be the same. By comparing Figs. 3 and 4 it will be seen that the curves B of the former are very much shorter than the curves C of the latter. Now air, iron, and steel offer a resistance to the flow of magnetism, and con-

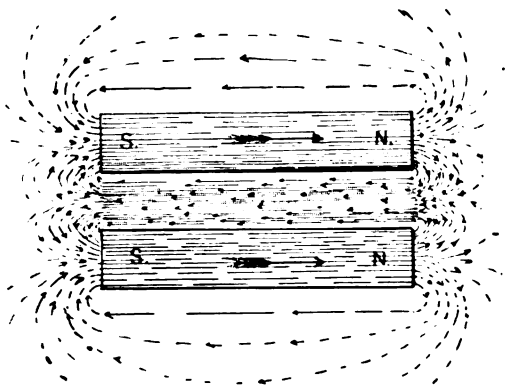


FIG. 6.

sequently, the longer the path in which the force acts, the weaker it must be if developed by an equal magnetizing force. The electric current is the magnetizing force, and the strength of magnetic force it will develop will be proportional, not only to the strength of the current, but also to the amount of resistance in the path of the magnetic force. If it were not for this fact, the magnetic force along the curve B in Fig. 2 would be just as great as that along curve D; but, as the latter curve is the shorter of the two, the force along it is the greatest. The greater the distance from the wire, the weaker the force, and at a comparatively short distance it becomes so weak as to be indeterminable. If the wire

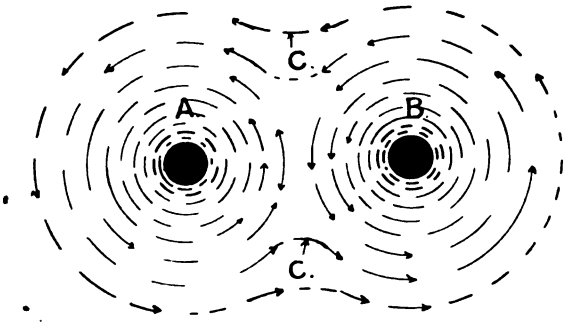


FIG. 7.

in coil B of Fig. 4 were made smaller than that in Fig. 3, so that it could be bunched into the same cross section, then the length of the magnetic path, or circuit as it is called, would be the same in both cases, and then the strength of the magnetism developed in Fig. 4 would be the same as that in Fig. 3 if the single current in the latter were equal to the sum of the current flowing in all the turns in the former.

A natural process of reasoning would lead us to infer that the longer the magnetic circuit the greater the resistance, and hence the weaker the magnetism, for it would be difficult to conceive that the strength of the magnetic force would be just the same at a distance from the wire, in Fig. 2, as near by. The action of magnets toward each other, as well as that between electric currents, serves to further illustrate the truth of this inference. The tendency of magnetism is to either shorten the circuit in which it acts to the greatest possible extent, or to increase the cross section of the path, or both. When two steel magnets are placed side by side with their poles in opposite directions, as shown in Fig. 5, they will attract each other, but if the poles are in the same direction, as shown in Fig. 6, they will repel. The

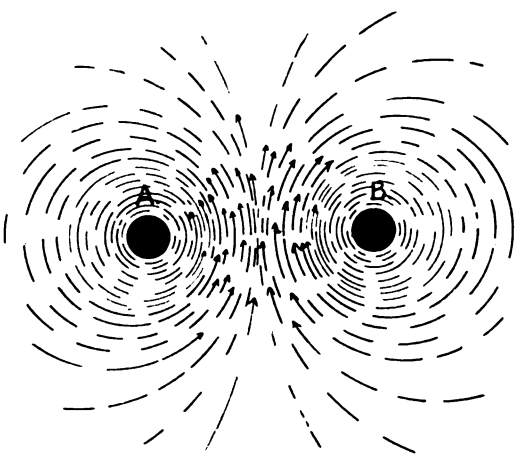


FIG. 8.

nearer they are to each other, in the first case, the stronger the attraction, and the further apart they are, in the second case, the weaker the repulsion. A study of the two figures will show why these actions take place, and also why in Fig. 5 the attraction in-

Digitized by Google

creases as the distance between the magnets is reduced, while in Fig. 6 the repulsion decreases as the distance is increased.

In Fig. 5 the direction of the magnetic force in the two magnets, being in opposite directions, each one forms a path through which the circuit of the other may pass. If the resistance of air and steel to the passage of the magnetic force were the same, the attraction between the two would not be very greatly increased by reducing the distance separating them, as the length of the circuit would only be reduced to a small extent; but the resistance of the air is many times as great as that of the steel, the difference being such that very nearly all the resistance opposed to the magnetic flow is that of the air—that is, of the path along the curves connecting the two ends of the magnets. This being the case, reducing the distance between the magnets, greatly reduces the total resistance opposed to the magnetic force. It might be supposed that the magnetic force, instead of following the curves shown at the ends of the magnets, would pass from one to the other in a straight line, as by so doing the path could be still further shortened, but if this were done the cross section of the path would be reduced, and this of itself would serve to increase the resistance; therefore the magnetism will spread out so as to reduce the resistance by widening its path as well as by shortening it. Some of the magnetism will begin to leak out before reaching the ends of the bars, as shown by the curves A, and some will spread out even further than indicated by the lines B.

In Fig. 6, as the poles of the magnets are in the same direction, one cannot serve as a circuit for the other, therefore the path of each will have to run through the space between the two—that is, for that part of the magnetic force that acts on the sides that face each other. If the intervening space is narrow, the magnetic force will tend to spread the bars, so as to widen its path and thus reduce the resistance in its path. In Fig. 6 the magnetism is shown as acting on all sides of the bars, while in Fig. 5 it is only shown along one path—that through the magnets. As a matter of fact, in both cases it will act in all the space surrounding the bars, but in Fig. 5 by far the greater part will be in the path shown, and when the two magnets are brought into actual contact there will be very little magnetism acting in the surrounding space. In Fig. 6, as the two magnets do not help each other, the effect will be to actually reduce the strength of the magnetism between the bars, and make it stronger at all other points. In the figure the lines between the bars are drawn closer together than on the outside, thus indicating that in this space the force is the greatest, but in reality it is not, owing to the fact that the cross section over which it acts is reduced. On the outside the magnetism is more diluted, so to speak, but the area over which it acts is very much greater. The actual condition of things is exaggerated in Fig. 6, so as to more clearly illustrate why magnets placed with their poles pointing in the same direction repel each other.

Wires carrying electric currents also repel and attract each other, but the action is just the reverse of that with magnets—that is, two currents flowing in the same direction will attract each other, and if in the opposite direction, they will repel. Why this is so can be seen from Figs. 7 and 8. In the first figure the current in both the wires A B is supposed to be running in the same direction. The wires are shown in section. The current being in the same direction, the flow of magnetism around both must be in the same direction; hence, the magnetism of both will meet, in the space between them, running in opposite directions. As a consequence, only that portion which is very close to the wire will keep to its true course; the remainder will join hands, as it were, with that of the neighboring wire and flow around the two wires, and by their contrasting tendency draw them together. This is indicated by the curves C.

In Fig. 8 the current in the two wires is supposed to be flowing in opposite directions, and, therefore, the direction of the magnetic force around the two will be in opposite directions. From this very fact, however, the direction of the two magnetic forces in the space between the wires will be the same; hence, all the magnetism of both wires will tend to crowd into this space, and as a result the wires will be forced apart.

News and Notes.

Recent British advices report the closing of the contracts between the British and Canadian Governments, and Petersen, Tate & Co., of Newcastle, for the equipment of the new fast mail and passenger line between Canada and the United Kingdom. The new boats, of which mention was made in our May issue, will be of not less than 10,000 tons gross register, and will have a sea speed of 21 knots. A fast tender of the torpedo boat type with a speed of 22 knots is to be provided at the Canadian end of the route.

One of the largest steam tugs on the Great Lakes is now under construction at the Bell Steam Engine Works, Buffalo. The boiler for this tug is to be furnished by Thomas Kingsford, Oswego, N. Y. This boiler is to be of the flat crown sheet type with double furnaces and single combustion chamber, each furnace 5 ft. by 6 ft. 6 in. long. Each furnace is to have four main fire flues 17 in. dia. Boiler will contain 196 tubes, 3 1-4 in. dia. by 12 ft. 4 in. long. Diameter of shell 12 ft. Length of boiler 16 ft. Steam drum 48 in. dia. by 8 ft. long. Height of boiler to top of shell 13 ft. 7 in. Boiler to be built for a working pressure of 150 lbs.

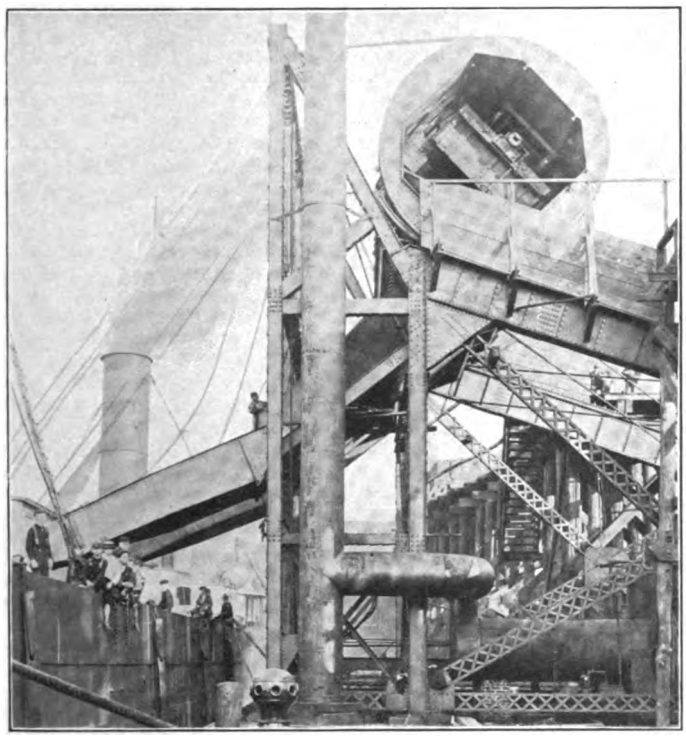
A collision at sea between trans-Atlantic liners occurred May 27, fortunately resulting in no loss of life and comparatively little damage to the vessels. The Atlantic Transport line steamship Mississippi from London for New York was run into in a fog, off the Banks, by the Thingvalla line steamship Hekla. The Mississippi was moving cautiously, having heard fog signals, when a big steamer was sighted approaching her on the port side amidships. The captain of the Mississippi put his helm hard over, and the Hekla at the same time reversed her engines. The blow was a glancing one, the Hekla ramming the port quarter of the Mississippi, tearing a big hole in her skin well above the water line, and carrying away several feet of the rail. The Hekla backed off with her bow crushed in to a point near the water line, and leaving part of her plating, a hawse-pipe and cable and anchor on board the Mississippi. The steering gear of the latter was damaged, but repairs were promptly made and she proceeded on her way, reaching this port safely June 1. The Hekla also continued her voyage, reaching Christiansand with passengers and cargo in good condition.

Digitized by Google

HOME AND FOREIGN EXCHANGES.

The Long Coal Car Dumping Machine.

The essential feature of the machine is a large cylinder constructed for receiving a car filled with coal and turning it upside down, discharging the coal into chutes which guide it into the hatchways of the vessels being loaded. The illustration, Fig. 1, is reproduced from a photograph showing a general view of the machine. Fig. 2 shows the cylinder with a car in place ready for dumping, and Fig. 3 shows the telescopic chutes filled with coal ready for discharging. The cylinder is 40 ft. long, has a clear internal diameter of 11 ft., an external diameter of 16 ft., weighs 40 tons, is constructed entirely of steel, and is supported at each end by two heavy steel T rails. The level of the railway tracks at the point where it was desired to locate the machine was about 28 ft. above the dock level, and therefore in order to meet these conditions the cylinder was supported on a steel superstructure and placed on a level with the existing tracks. This makes a practical and convenient plant, as the space beneath is an ideal location for the power plant and operating machinery.

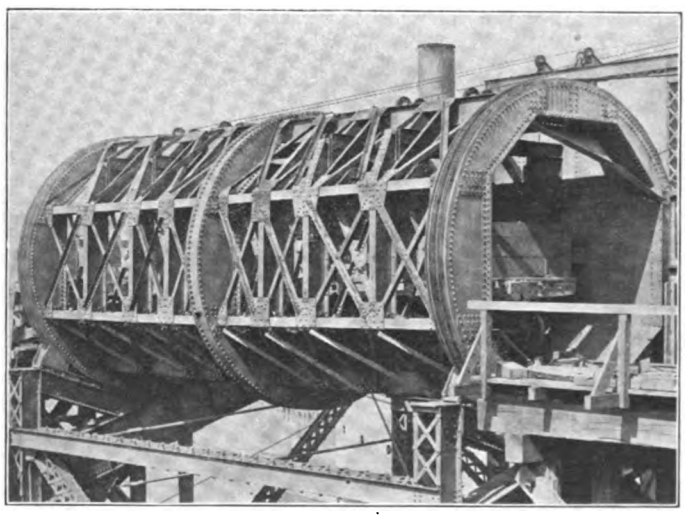


LONG CAR DUMPING MACHINE.—FIG. 1.—GENERAL VIEW.

The cylinder in dumping a car is simply rolled along its supporting track by means of wire ropes, which are passed around its periphery. A double cable is used at each end of the cylinder, and after being passed around the cylinder is carried over sheaves and down to a steam cylinder 30 in. dia. and 10 ft. long, which lies in a horizontal position at the base of the superstructure. This cylinder contains a piston, which is by means of a piston rod attached to a crosshead, which also carries the lower end of the cables referred to. Steam pipes are arranged for admitting steam to either end of the cylinder, but under ordinary conditions steam is applied only for dumping, as the track on which the dumping cylinder rolls is placed on an incline, and it will return to its normal position by gravity, and in so doing carry the piston and cables with it. Between the rails which form the track upon which the cylinder rolls there are a series of steel pins about 4 in. in diameter, which engage with a series of corresponding holes in the cylinder, thus insuring that the travel of the cylinder will be equal on both ends and also that there will be no slipping.

The machine is operated from a small platform located at one end, where both the apparatus and the vessel being loaded are in plain view. There are only two operating levers used. One of these controls the pair of hydraulic cylinders which are used in holding supports against the lower side of the car as it is being dumped. The other lever admits and discharges steam to the operating cylinder. This operating lever gives the operator absolute control of all motions of the cylinder and by simple manipulations of this he can roll a car load of coal which, together with the cylinder, weighs about 80 tons, as though it were only a feather's weight.

An important feature of the apparatus is the telescope chutes shown in Fig. 3. By their use the breakage of coal is reduced to a minimum. The chutes are arranged on an angle of about 45°, so that the coal does not have a direct drop, but slides down the incline at a speed which is not sufficiently great to break it. In order to still further avoid breakage, controlling doors are arranged on the lower end of each chute, and before any coal is discharged these doors are closed tight, the chutes are then filled, and by means of the doors the flow of coal is under absolute control. Each chute is supported by wire cables, which are controlled by a pair of hoisting engines and operated from the same platform as the dumping apparatus. By means of these cables the chutes may be moved about and raised and lowered to any posi-



LONG CAR DUMPING MACHINE.—FIG. 2.—DUMPING CYLINDER.

Digitized by Google

tion allowed by the dimensions of the hatchways. It is stated that the operator has such control over these chutes that trimming is a comparatively simple and inexpensive operation.

Only three men are required for handling the entire machine. These are an engineer and fireman, both of these positions being filled by one man; one man to operate the cylinder, and a third to control the movements of the chutes. The machine has handled 300 cars or 7,500 tons of coal in a day of ten hours, and the reduction in the cost of loading vessels has been such as to almost revolutionize the coal business at the point where the machine is in operation. The machine is equally well adapted to use in taking cars from the dock level and dumping them into the hatchway of a vessel by a simply arranged incline.

The machine at "Erie" docks in Cleveland, Ohio, unloaded over it last season, from the 10th day of April to the first of December, 23,155 cars, amounting to 550,127 tons of coal, and could have unloaded half as much more if the shippers had had the customers, coal and boats.

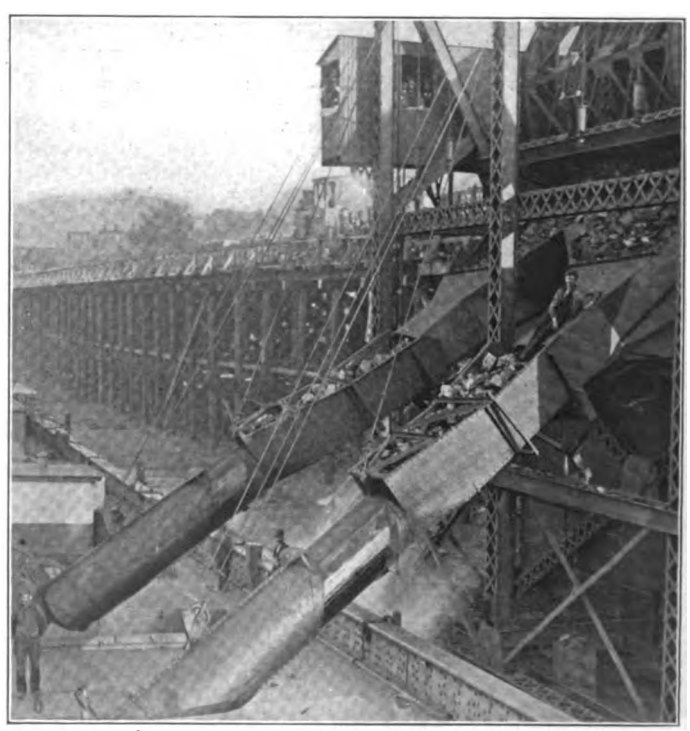
The Excelsior Iron Works is now working on a Long coal car unloading machine, to be erected at Conneaut, O., on the P. S. & L. E. R. R. docks, Carnegie's coal and ore dock, which will be the finest on the lakes.

For the description of this apparatus and the illustrations here used, we are indebted to the courtesy of The Coal Trade Journal.

Comment on the Use of Nickel Steel in Ships.

There would appear to be no doubt that nickel steel is destined to be much more extensively used at an early date. For armor plate purposes its use is rapidly extending, and it is also notable that for important forgings, such as those required for crank and propeller shafting and connecting rods, it has been adopted in the Japanese battleship at present being built on the river Thames. In the adoption of nickel steel for marine engine purposes, United States engineers, however, were the pioneers, this material being used for the shafting and piston rods of the engines of the Fall River Line steamers, and the United States war vessels Columbia and Cincinnati, and for propellers in torpedo boats. The American Line steamer Paris was the first merchant vessel to be supplied with a length of shafting of nickel steel, and in the three years that have since elapsed further progress has been made in introducing the material in another direction, viz., in the construction of marine boilers. In our present issue, says the Engineers' Gazette, we give an illustrated description, from our latest American contemporary, of the boiler which has been built of nickel steel for the United States Cruiser Chicago. Originally, it had been intended that the four cylindrical boilers of the Chicago were to be of nickel steel, and the plates were ordered and delivered, but the greater part had to be condemned, owing to being badly pitted and scored, as though slag had been amalgamated with the material. From the same cause only the boiler shell was formed of nickel steel plates, the internal plates and stays, as well as rivets, being of ordinary steel. It is also stated that the extra cost for labor, owing to the difficulties that occurred in working the nickel steel plates, was considerable. This is quite contrary to the testimony of Mr. William Beardmore, who, in his paper read before the recent meetings of the Institution of Naval Architects on "Nickel Steel as an Improved Material for Boiler Steel Plates, Forgings, and Other Purposes," stated "nickel steel can be bent and punched quite as successfully as ordinary carbon steel." It may be that the plant employed in bending the nickel steel boiler plates of the Chicago were inadequate, seeing that in the process "the housings of the biggest rolls in the boiler shops were smashed," but it is also stated that "the edges of cutting tools were turned or fractured," presumably in planing the edges of the plates.

Doubtless, practical difficulties do arise in dealing with new materials, but they are usually soon overcome, and possibly in the case of the boiler of the Chicago they have been unduly magnified. In two American gunboats part of the shell plating is of nickel steel one inch thick, and little difficulty was experienced in rolling these plates, and the surfaces were satisfactory. Further, Mr. J. G. Eaton, of the U. S. Navy, states in a communication to the Iron and Steel Institute, "no trouble was experienced in machining and fastening this material;" and further, that it was "certainly proved that nickel plates in this form could be successfully used in ship construction, and that the only increase in cost came from the cost of the nickel in the alloy." In one respect, and that a most important one, viz., as to the relative immunity that nickel steel has from corrosion, there is a practical uniformity of testimony. At the conclusion of the description of the boiler on the Chicago on another page, it is stated "the corrosion resisting qualities of the material were shown in the pickling. It took just five times as long to dissolve the scale on the nickel plates as it did on the carbon plates." It can scarcely be said, however, that this slowness in getting rid of the mill scale is positive proof of the anti-corrosion quality of nickel steel. Ordinary iron ship-plates lose the mill scale more readily than Siemens-Martin steel, but in practice the latter is generally found to corrode more rapidly. Mr. Henry A. Wiggins, of Birmingham, found, in an experiment on a small



LONG CAR DUMPING MACHINE.—FIG. 3.—TELESCOPE CHUTES.

Digitized by Google

scale, extending over three months, that nickel steel in 10 per cent salt water kept at a boiler temperature corroded only about half as much as open hearth steel under the same circumstances. Similarly when subject to steam, the nickel steel showed an advantage of about 25 per cent. Mr. William Beardmore, in his paper already referred to, gives the results of experiments carried out at Leith Docks extending over twelve months, and in this instance nickel steel had more than 20 per cent the advantage of mild steel. Should further experience confirm those results, and it be found that nickel steel can better resist the effects of alternate heat and cold, and can dispense with anti-corrosive coatings, then, despite its enhanced cost, it might speedily come into use for those parts of the hulls of vessels that are peculiarly liable to corroding tendencies, owing to their inaccessibility for cleaning and painting and their proximity to the boilers, and for deck plating, where, owing to the constant traffic, together with exposure to the weather, it is extremely difficult to keep the surfaces coated with paint or other similar material. It is also probable that it would become a favorite material for propellers.

Corrosion in Steam Vessels Remedied.

Soon after the application of steel in the construction of the English coasting steamer, with the consequent diminution of thickness allowable with that highly tenacious material, it was found that the forward part of the bottom of these vessels, for a few feet before the collision bulkhead to about ten or twelve feet abaft, became, after a few months' work at sea, very much more corroded than elsewhere. The countersunk points of the rivets were found pitted, the rivets sometimes were loose, and the shell plating was so much set in between consecutive floors as to suggest that the vessels had been ashore. Associated with this phenomenon was a wasting of the lower edges of the outer strakes of plating at the same part of the bottom, and this wasting proceeded at such a rapid rate that after two or three years' service it had extended to the rivets in the lap of the plate edges.

Considered by itself, the setting-in of the plating between the floors and the loosening of the rivets attaching it to the frames, seemed to point to a straining effect due to the weight of the large body of water carried in the fore-peak tank for trimming purposes when steaming without cargo. Measures were at once taken for reducing the depth of the fore-peak tank and for affording a stronger connection between the peak bulkhead and the hull of the vessel. But, despite continued efforts in both directions, the mischief still went on, until the wasting of the plate edges and the corrosion of the rivets suggested that some other cause was at work than had at first been suspected.

It was ultimately discovered that, although an undue and, as it turned out, unnecessary weight of water in the fore-peak tank had produced some straining effect in the vicinity of the peak bulkheads, yet the principal cause of the phenomenon was the violent pitching movement of the vessel when driven head to sea in a light condition. For, with the machinery right aft, the vessel necessarily trims by the stern, even with the fore peak filled with water. Whether the tank be large or small, the pitching motion, when driving head to sea, is a frequent one, and the forward immersion being but small, it follows that the comparatively bluff bow repeatedly rises and falls with a thump on the approaching sea.

The relatively thin steel plating was thus, in the course of time, set in between consecutive floors, while the atmospheric air, imprisoned between the "luff of the bow" and the sea at every plunge, acted corrosively upon the surface of the plating and the countersunk points of the rivets and the lower landing edges of the outer strakes in the same way as it does upon the forward upper edge of a screw propeller blade.

When once the cause of the mischief was discovered, a remedy was speedily found. Floors at alternate frames, while sufficiently close at the other parts of the vessel on the fore side of the machinery space, were evidently too far apart to properly stiffen the plating where these blows were received without something more rigid than an ordinary frame angle between them. Hence the intermediate frame angle bars were replaced with six-inch bulb angles throughout that portion of the length of the bow where the mischief was found to extend.

For the rest, the shell plating was increased at the bow to at least the same thickness as in the strakes amidships, and the edges of the troublesome strakes were arranged in boat-plank fashion. In this way the plating was sufficiently stiffened to stop the vibratory movement that had loosened the rivets, and sufficiently thickened to allow a deeper and better countersink for those rivets. Moreover, the imprisonment of air bubbles at the landings, with the consequent wasting by corrosion, was prevented and the evil was cured. The plating still rusts more readily there than elsewhere, but this is remedied by frequent painting.—J. S. P. Thearle in Cassier's Magazine.

The "Oceanic's" Stern Frame.

The Darlington Forge Company are now engaged in preparing the stern frame and brackets for the new White Star liner from steel castings made by them, and which are the largest of the kind ever produced in this country, says the Shipping World, of London. The stern frame is in one piece, and as a casting weighs 41 tons, and when completely machined and ready for erection will weigh 35 tons. Its height is 53 ft. by 24 ft. 3 in. over the keel piece, the section of the post being 21 in. by 11 in. Attached to this frame are the after brackets, a huge casting also in one piece, which will weigh 55 tons as it leaves the foundry, and 45 tons when machined and erected in position. The height of the flanged portion of the bracket—that which is attached to the frame of the ship—is 26 ft., whilst the width from center to center of the bosses is 23 ft., the bosses themselves being 4 ft. 3 in. dia., by 5 ft. 7 in. deep. The forward brackets, which are entirely built within the plating of the vessel, will weigh 30 tons when machined and erected.

Contracts for 180,000 tons of coal have been let in England by the Cunard Steamship Company, the prices varying from $2.35 to $2.50.

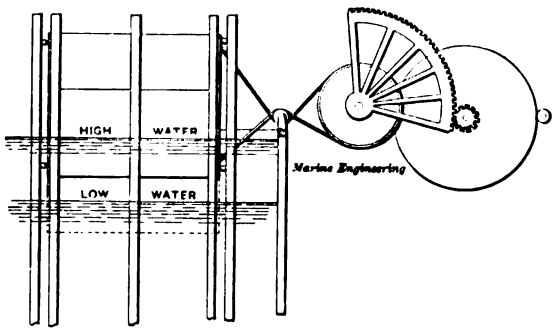
James Davidson, shipbuilder, West Bay City, Mich., has just completed a steamship 285 ft. long, 44 ft. beam, and 26 ft. depth. This steamship has triple expansion engines, Howden system of forced draft, steam steering gear, steam windlasses, steam capstan, and a complete electric light plant. There are also on the stocks at this yard, nearly ready for launching, two large schooners, each of which is 300 ft. long, 45 ft. beam, and 25 ft. molded depth. These schooners each have three spars, supplied with sails, and they also have large pony boilers, steam windlasses, steam deck hoists, and steam pumps. In addition to the above there are also nearing completion three large tugs, two of which will go to Duluth, Minn., and one to Chicago, Ill.

Digitized by Google

SELECTED PATENTS.

582,931—STEERING GEAR FOR SHIPS. *Frank E. Kirby, Detroit, Mich., assignor to the Detroit Dry Dock Company. Filed Dec. 24, 1896.*

The combination with a rudder stock and a steam steering gear adapted to operate the same, of a tiller secured to the stock, a tiller loosely sleeved on the stock, a locking device on the loose tiller adapted to automatically connect the two tillers together, means for holding and locking the device out of engagement,



SAGER TIDE MOTOR.

and a hand steering gear connected with the loose tiller. The combination with a rudder stock and steam steering gear, of two tillers, one rigidly secured to and the other loosely mounted upon the rudder stock, an arm pivoted to the loosely mounted tiller, and provided with a yoke for engaging the rigidly secured tiller, and a lever for holding the yoke from engagement with the rigidly secured tiller. The combination with a rudder stock, and a steam steering gear for operating the same, of two tillers, one rigidly secured to and the other loosely mounted upon the rudder stock, an arm pivoted to the loosely mounted tiller and provided with a pendent yoke to embrace the rigidly secured tiller, and a lever pivoted to the arm for holding it elevated with the yoke disengaged from the rigidly secured tiller.

583,821—TIDE MOTOR. *Eli E. Sager, Duluth, Minn., assignor of one-half to Peter Gilley, same place. Filed Mar. 15, 1897.*

The combination with vertical guides, and a float-body mounted for vertical movement, of a pulley located at one side of the float-body, a drum rotatably supported in advance and in line therewith, cables connected to the float-body near the upper and lower ends and passed in reverse directions about the pulley and beyond the same passed in reverse directions about and fastened to the drum, a toothed sector rocked by the drum, and a train of gearing operated by and connected to the sector. The combination with vertical guides, and a float-body mounted for vertical movement therein, of a plurality of pulleys located at the side of the float-body, a corresponding number of drums supported for rocking and aligning with the pulleys, pairs of cables carried over pulleys and secured to drums, as described; a shaft for supporting the drums, and means for conveying motion therefrom. The combination with the series of guide posts or standards located as shown, the float-body, and the anti-friction rollers mounted on the latter and riding over the posts, of the breakwater, the bearings supported thereon, the pulleys journaled therein, the opposite side frames, the main shaft mounted in bearings thereon, the large drums carried by the main shaft, the pairs of cables connected to the upper and lower ends of the float-body and passed in reverse directions about and secured to the drums, toothed segments of greater diameters than the pulleys and drums mounted on the main shaft, a transverse shaft journaled in the side frames, small gears carried thereby and meshing with the sectors, large gears carried by the transverse shaft, a crank shaft journaled in bearings on the side frames, small gears carried thereby and driven by the gears of the transverse shaft, and a pitman rod connected to the crank portion of the crank-shaft.

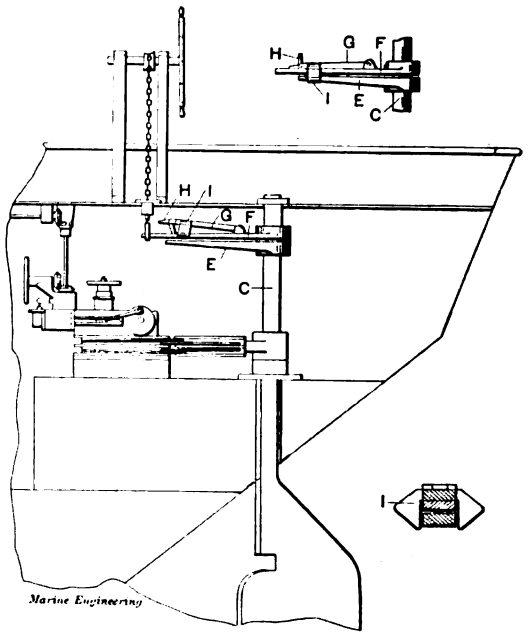
CATALOGUES.

The Hyatt Roller Bearing Co., Havemeyer Building, New York, has just issued its 1897 catalogue, which gives in full detail the various uses of this company's roller bearing.

J. N. Hayden & Co., Grand Rapids, Mich., did not propose that their catalogue should be destroyed when it was published, so it was printed on asbestos paper. The catalogue describes in full detail the "Globe" box metal, and gives directions for using it, in addition to letters regarding it which have been received from customers.

A general catalogue has just been published by the Lake City Engineering Co., Erie, Pa., regarding centrifugal pumping machinery and marine engines. These two devices are the specialties made by this company, and information enough is contained in this catalogue to give a very excellent idea of what they are like. The catalogue is very convenient in form, and the press work is very clear, an extra quality of paper being used.

The 1897 catalogue of the New Britain Machine Co., New Britain, Conn., is just ready for distribution. It is an exceptionally fine specimen of the printer's art, having a dark green cover printed in gold, while the text is in black, with headings in red. Most of the pages are devoted to the chain saw mortiser, manufactured by this company, a very remarkable tool for finishing woodwork for vessels and

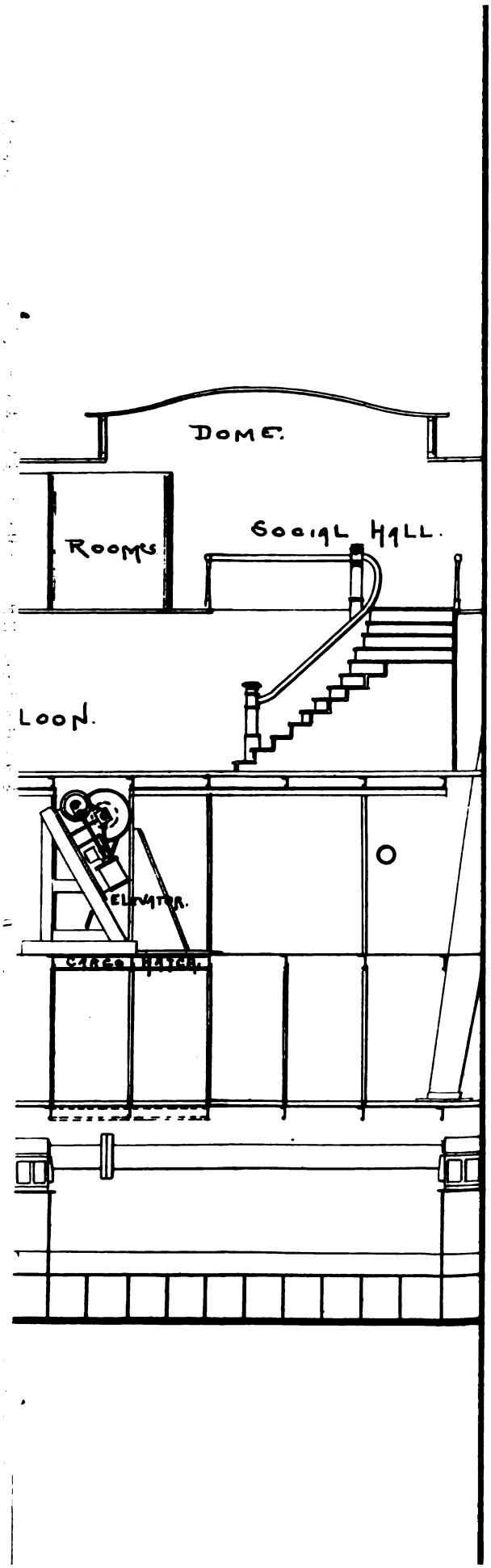


KIRBY STEERING GEAR.

other uses. The well-known Case steam engine is also illustrated and described.

The 3-4 H. P. gas engine, manufactured by the Pierce Engine Co., Racine, Wis., is described and illustrated in full detail in a catalogue just issued by this company. The printing is black with red headings, and several illustrations add to the value of the text. This company has found such a demand for this size of engine that up to the present time it has limited itself to this one engine for boats designed

Digitized by Google



Digitized by Google

Digitized by Google